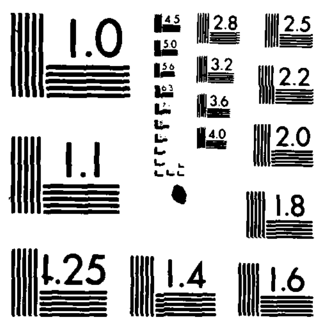
AD-A115 457 TRW DEFENSE AND SPACE SYSTEMS GROUP REDONDO BEACH CA F/G 9/2
A STUDY OF EMBEDDED COMPUTER SYSTEMS SUPPORT. VOLUME V. REQUIRE--ETC(U)
SEP 80 F33600-79-C-0540
UNCLASSIFIED TRW-34330-6003-UT-00-VOL- NL

1 of 2



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A STUDY OF
EMBEDDED COMPUTER SYSTEMS SUPPORT

VOLUME V

REQUIREMENTS BASELINE: COMMUNICATIONS-ELECTRONICS

September 1980

APPROVED FOR PUBLIC RELEASE
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CDRL 02A
Contract Number F33600-79-C-0540

Prepared for
Air Force Logistics Command AFLC/LOEC
Wright Patterson AFB, Ohio 45433

UNCLASSIFIED/UNLIMITED

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A115457	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Embedded Computer System Support Volume 5- Requirements Baseline: Communications-Electronics		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER 47169E
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s) F33600-79-C-0540
9. PERFORMING ORGANIZATION NAME AND ADDRESS TRW Systems Inc One Space Park Redondo Beach, CA 90278		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS HQ AFLC/LOEE Wright-Patterson AFB, OH 45433		12. REPORT DATE Sept 1980
		13. NUMBER OF PAGES 142
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release, Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Recommendations pertaining to administrative and programmatic initiatives are presented in this volume. Companion document dated October 1981, September 1980, same contract number.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Materiel Management	ECS	Computerized Systems
Logistics Support	Weapons Systems	Avionics
Logistics Management	Technology Forecasts	
Planning	Program Management	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The primary focus of this portion of the overall study was to establish Embedded Computer Systems (ECS) support baseline for representative Communications-Electronics (C-E) systems. The baseline was then used as a reference point for assessing the current level of ECS support and for identifying deficiencies in projected C-E support systems. This baseline will also serve as a point of departure for developing a long range Communications-Electronics ECS support plan. (See related volumes: LD 47169A, B, C, D, F, G,

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ITEM 20 (con't)

H, J, K and L).

Conclusions: See volume 1 (LD 47169A).

Recommendations: See volume 1 (LD 47169A).

34330-6003-UT-00

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FOREWORD

This volume is one of nine individually bound volumes that constitute the Phase II Final Report "Study of Embedded Computer Systems Support" for Contract F33600-79-C-0540. The efforts and analyses reported in these volumes were sponsored by AFLC/LOEC and cover a reporting period from September 1979 through September 1980.

The nine volumes are

Volume	Title
I	Executive Overview (CDRL 05)
II	Selected ECS Support Issues: Recommendations/ Alternatives (CDRL 02A)
III	Requirements Baseline: Aircrew Training Devices (CDRL 02A)
IV	Requirements Baseline: Automatic Test Equipment (CDRL 02A)
V	Requirements Baseline: Communications-Electronics (CDRL 02A)
VI	Requirements Baseline: Electronic Warfare (CDRL 02A)
VII	Requirements Baseline: Operational Flight Programs (CDRL 02A)
VIII	ECS Technology Forecast (CDRL 03)
IX	National Software Works Investigation (CDRL 04)

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CONTENTS (Continued)

CONTENTS (Continued)

TABLES

ILLUSTRATIONS

ABBREVIATIONS AND ACRONYMS

AAC	Alaskan Air Command
ACE	ASIT Communications Equipment
ADCOM	Air Defense Command
AFCC	Air Force Communications Command
AFLC	Air Force Logistics Command
AISF	Avionics Integration Support Facility
ALC	Air Logistic Center
ASIT	Adaptable Surface Interface Terminal
ATC	Air Traffic Control
ATD	Aircrew Training Device
ATE	Automatic Test Equipment
AWACS	Airborne Warning and Control System
BMEWS	Ballistic Missile Early Warning System
BUIC	Back-Up Interceptor Control
CC	Central Computer
CCB	Configuration Control Board
C-E	Communications-Electronics
CM	Configuration Management
CMB	Configuration Management Board
CP	Communications Processor
CPCSB	Computer Program Configuration Sub-board
CPCI	Computer Program Configuration Item
CRB	Configuration Review Board
CRISP	Computer Resources Integrated Support Plan
CRWG	Computer Resources Working Group
DAPG	Data Analysis and Processing Group
DT&E	Development Test and Evaluation
ECS	Embedded Computer System
ESD	Electronic Systems Division
EW	Electronic Warfare

ABBREVIATIONS AND ACRONYMS (Continued)

FIS	Fault Isolation Software
FOT&E	Follow-On Test and Evaluation
GCA	Ground Control Approach
GEODSS	Ground Electro-Optical Deep Space Surveillance System
HIT	Hughes Improved Terminal
IC	Integrated Circuit
IOT&E	Initial Operational Test and Evaluation
ISA	Interface Simulation Analyzer
ISF	Integration Support Facility
ISS	Interface Standard Group
JINTACCS	Joint Interoperability Tactical Command and Control Systems
JSE	JTIDS System Exercisor
JSS	Joint Surveillance System
JTIDS	Joint Tactical Information Distribution System
LCC	Landing Control Central
LCC	Life Cycle Cost
LRU	Line Replaceable Unit
MARS	Minimally Attended Radar System
MDR	Material Deficiency Report
MOA	Memorandum of Agreement
MOB	Main Operating Base
NDHQ	National Defense HQ (Canada)
OC	Oklahoma City, Oklahoma
OCP	Operational Computer Program
OFP	Operational Flight Program
OO	Ogden, Utah
O&M	Operations and Maintenance
O/S CMP	Operational Support Configuration Management Procedures
OT&E	Operational Test and Evaluation

ABBREVIATIONS AND ACRONYMS (Continued)

PAR	Precision Approach Radar
PCB	Printed Ciruit Board
PCD	Program Change Document
PM	Program Manager
PMR	Program Modification Request
PMRT	Program Management Responsibility Transition
PROM	Programmable Read Only Memory
RAM	Random Access Memory
ROCC	Region Operations Control Center
ROM	Read Only Memory
RSSF	ROCC Software Support Facility
SA	San Antonio, Texas
SAC	Strategic Air Command
SAGE	Semi-Automatic Ground Environment
SCRB	Site Configuration Review Board
SHS	System Hardware Support
SM	Sacremento, California
SMF	Software Maintenance Facility
SOCP	Simulation Operational Computer Program
SPA	System Programming Agency
SPO	System Program Office
SRU	Shop Replaceable Unit
SSE	System Support Element
S&W	Surveillance and Warning
TAC	Tactical Air Command
TACS	Tactical Air Control System
TADS	Tactical Air Defense System
TAF	Tactical Air Forces
TAFB	Tinker Air Force Base

ABBREVIATIONS AND ACRONYMS (Concluded)

TCTO	Time Compliance Technical Order
T&D	Test and Diagnostic
TDC	Target Data Computer
TMP	TMDA Message Processor
TMSS	Test and Maintenance Support Station
TOCP	Test Operational Computer Program
TP	Translator Processor
TPU	Transceiver Processor Unit
TRACALS	Traffic Control and Landing System
TSISC	Tactical Systems Interoperability and Support Center
WR	Warner Robins, Georgia

1. COMMUNICATIONS-ELECTRONICS EMBEDDED COMPUTER SYSTEMS

1.1 INTRODUCTION

The Communications-Electronics (C-E) category of Embedded Computers Systems (ECS) embraces a wide variety of ground based and airborne weapon and support systems. Of all the ECS categories C-E is the most complex interim of system types, number of users/support agencies, and missions. In addition, the complexity of ECS support is growing at a non-linear rate, as more systems are added to each category and each new system becomes more technically complex than the previous one.

The primary focus of this portion of the overall study was to establish an ECS support baseline for representative C-E systems. The baseline was then used as a reference point for assessing the current level of ECS support and for identifying deficiencies in projected C-E support systems. The baseline will also serve as a point of departure for developing a long range communications-electronics ECS support plan.

The responsibility for supporting certain C-E category ECS systems is shared by AFLC with the using commands; e.g., TAC, SAC, and AFCC. The precedent for this support concept was established by the Jumper-Snavely Agreement of 1970. The specific degree of sharing is established via a Memorandum-of-Agreement (MOA) between AFLC and the system's user organization.

An additional factor which impacts on C-E management is the total number of ALC's providing ECS support. All ALC's except San Antonio support C-E systems, with Sacramento serving as the prime support center for C-E systems.

1.2 DEFINITIONS

1.2.1 Communications-Electronics

C-E weapon systems and their associated ECS's and software programs are defined to be those systems that perform the functions of command and control, communications, surveillance and warning, air traffic control, intelligence, and meteorological support.

1.2.2 Integration Support Facility

An engineering facility established to support weapon system embedded computer systems. It is made up of people, equipment, physical and environmental facilities, data, documentation, and procedures. Its uses may include the capability to simulate missions, evaluate computerized systems or subsystems, test modifications, and integrate hardware, software, and man/machine interfaces. It also provides a capability for baseline and configuration management of software configured items.

1.2.3 Software Support Facility

A facility established to develop, support, and maintain operational software for embedded computer system. It is made up of people, equipment data, documentation and procedures necessary to develop, code, compile, assemble, check-out, test, and maintain operational mission software. These facilities lack the capability to conduct systems integration and testing.

1.2.4 Command, Control and Communications

The process of and the means for the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the commander's mission. Command, Control and Communications (C^3) functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures that are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the commander's mission.

1.2.5 Command, Control and Communications Countermeasures

The integrated use of operations security, military deception, jamming, and physical destruction, supported by intelligence, to deny information to, influence, degrade, or destroy adversary C^3 capabilities and to protect friendly C^3 against such actions.

1.3 C-E SYSTEM IDENTIFICATION

The data collection activity has identified fifty C-E systems that are either currently operational or in some phase of the pre-PMRT acquisition cycle. The exact number of C-E systems which should be considered in this category is in doubt because the using commands often categorize systems differently than the supporting commands. Table 1-1 lists the C-E systems considered in this study. The representative systems selected for the baseline evaluation are highlighted with asterisks. Each system is identified by the system number, its commonly used short title, its full title, and selected remarks. The table groups these systems into the six functional C-E areas: command and control, communications, meteorological, surveillance and warning, air traffic control, and intelligence systems.

1.4 C-E SYSTEMS DEVELOPMENT

The C-E category embedded computer system encompasses several different sets of military missions and lacks the specific focus of the other ECS categories such as EW or ATD. In addition to this wide diversity of missions, the C-E category must address both modern weapon systems entering the inventory as well as those systems which were operational prior to the development of ECS support concepts. In many cases ECS support has grown out of early ADPE requirements. Initially, in the late 1950's and early 1960's, computers were used to process mission data (radar signals, displays, etc.) and were not integrated into the system hardware. However, with the advent of

Table 1-1. C-E Systems

System	System No.	Short Title	Program Title	Remarks
Surveillance and Warning	474L	BMEWS	Ballistic Missile Early Warning System	
	474L		BMEWS Update	
	2059	PAVE PAWS	SLBM Phased-Array Radar Warning System	Phased-Array Radar for SLBM S&W (Two Sites)
		EPARCS	Enhanced Perimeter Acq. Raid Char. System	Modify the SAFEGUARD Radar for S&W
	414L	OTH-B	CONUS O-T-H Backscatter Radar System	Supplement NORAD S&W of Penetrating Aircraft
		SEEK FROST	DEW Line Replacement Radar System	Replace the DEW Line with MARS
	2433†	SEEK IGLOO	Alaskan Air Command - MAR System	Replace 13 AAC Radars with a MAR
	968H†	JSS	Joint Surveillance System	Replacement for SAGE/BUIC
	496L	SPACE TRACK	SPACE TRACK System - Shemla Is. Alaska, Turkey	
	633A	COBRA DANE	Phased-Array Radar System - Shemla Is. Alaska	Phased-Array Radar Collects USSR Missile Intelligence
	2295	GEODSS	Ground-Based E-O Deep Space Surveillance System	Deep Space Surveillance (Basketball at 22,000 miles)
		TEAL AMBER	GEODSS Follow-on CCD Sensor	
	633B	COBRA JUDY	Shipborne Phased-Array Radar System	Shipborne Phased-Array Radar (USSR Intelligence)
	AN/GPQ-27	RAPS	Radar Prediction System	
	474N	SLBM-S&W	SLBM Radar S&W System	DMTS - Diagnostic Monitor Test System
Air Traffic Control	404L†	TRACALS	Traffic Control Approach and Landing System	Fixed and Mobile Approach Control and Landing Systems
		GPS-NAVSTAR	Global Positioning System	
	450A	LORAN C/D	Long Range Navigation C/D	Transportable Loran C
Intelligence	428A	IITS	Intra-Theater Imaging Transmission System	
		TIPI	Tac Info Processing and Interepretation System	Air Transportable System in Mobile Shelters
		OASIS	Operational Application Special Intell System	Support USAFE's TFC for AAFCE
		BETA	Battlefield Exploitation & Target Acquisition Sys.	

† Selected for baseline evaluation.

Table 1-1. C-E Systems (Concluded)

System	System No.	Short Title	Program Title	Remarks
Command and Control	416L	SAGE	Semi-Automatic Ground Environment	
	416M	BUIC	Back-Up Interceptor Control	
	465L	SACCS	SAC Automated Command Control System	NMCS
		NMCS	National Military Command System	Includes NMCC, MEECN, 481B
		CCPDS	Command Control Processing Display System	
	427M	NORAD	NORAD Cheyenne Mountain	NORAD's Cheyenne Mountain C^2 Complex
	407L	TACS	Tactical Air Control System	
	485L	TACSI	TACS Improvement	Program to Automate USAF's TACC Functions
	411L †	AWACS	Airborne Warning and Control System, E-3A	USAF-34 Systems, NATO-18 Systems (Modified B-707)
	481B	AABCP	Advanced Airborne Command Post, E-4B	USAF-4 to 6 Systems (Modified B-747)
		SEEK SCORE	SAC Radar Bomb Scoring System	SAC Bomb Scoring System for Training
	AN/TSQ-96		SAC Bomb Scoring System	
	AN/TPB-1C		Ground-Based Radar Directed Bombing System	
		DTCS	Drone Tracking Control System	
		PLSS	Precision Location Strike System	Includes ALSS (Classified), Four sites
Communications	490L	TDCS	Trafic Data Collection System	
		SCOPE SIGNAL	USAF Worldwide HF/SSB Communications System	
	1144	ATEC	Automated Technical Control	Provides Computer-Aided Performance Assessment
	2206	DEB	Digital European Backbone	Transition from Analog to Digital Communications
	1205	AFSATCOM	AF Satellite Communications System	Program to Provide UHF airborne/ground terminals
	1136	SACDIN	SAC Digital Information Network	Provides an Integrated SAC Digital Comm System
	478T	CTC-TCCF	Combat Theater Communications (TRI-TAC)	TCCF Includes CNCE, CESE, CSPE, CSCE
	2283 †	JTIDS	Joint Tactical Information Distribution System	Develop a Complete Digital Communications System
		EC-135	Digital C-135 Communications System	Being Replaced by E-4B (481B)
Meteorological		AWDS	Automatic Weather Distribution System	
		WSC	Wind Sounding Capability	

† Selected for baseline evaluation.

militarized minicomputers and microprocessors, many more system functions are now controlled by the computer in addition to the processing of mission data. It was this integration of hardware and computer software that forced the development of ECS support concepts outlined in AFR 800-14. The joint support of ECS systems by traditional support agencies and by the systems' operational users adds on additional dimension to the ECS support problem thus making the application of AFR 800-14 procedures critical to the effective management of the weapon system's configuration. Effective software and hardware configuration management can mean the difference between victory or defeat on today's highly complex and technical battlefield.

The implementation of new DOD programs designed to prepare C-E systems for tomorrow's battlefield will significantly impact ECS management in the near term. For example, the Command, Control and Communications Countermeasures (C^3CM) program will require additional resources not typically associated with traditional hardware systems support. The inherent flexibility of ECS software makes it an excellent candidate for the implementation of C^3CM in C-E systems.

1.5 OPERATIONAL STATUS/PMRT

The operational status of each C-E system identified previously in Section 1.3 is shown in Table 1-2. The table is presented to indicate the system status by including the system PMRT date. This date represents the time at which AFLC is to accept responsibility for supporting the system. Also included is the organization that will be responsible for providing software support. The software support philosophy is indicated; i.e., will software support be provided by a contractor, by an Air Force organic organization, or by an organic/contractor combination. The final column identifies the user command.

Table 1-2. C-E Systems Operational Status

System	System No.	Short Title	Program Status	PMRT Date	Software Support Responsibility	Software Support Philosophy	User Command
Surveillance and Warning	474L	BMEWS	Operational	1961			
	474L	B-Update	Development and Acquisition	Jun 1980	T&D/SM-ALC		
	2059	PAVE PAWS	Operational	1979	ADSAC	Contractor	SAC
		EPARCS	Conceptual				
	414L	OTH-B	Development and Validation	Jan 1981	TBD		NORAD
		SEEK FROST	Design	Jun 1987			
	2433	SEEK IGLOO	Development and Acquisition	Jun 1984	SM-ALC (T&D, Operational)		AAC
	968H	JSS	Implementation	Dec 1982	User (T&D, Opnl); SM-ALC (PROM)	Organic	ADCOM
	496L	SPACE TRACK	Operational		T&D/SM-ALC; Opnl/ADCOM	Organic/Contractor	ADCOM
	633A	COBRA DANE	Operational	1978	T&D/SM-ALC; Opnl/AFSC	Contractor	ADCOM/FTD
		TEAL AMBER		1981			
	633B	COBRA JUDY	Acquisition				
	AN/GPQ-27	RAPS		Nov 1983	SM-ALC	Organic	TAC
	474N	SLBM-S&W	Operational	1980	SM-ALC	Contractor	ADCOM
	2295	GEODSS	Acquisition	Apr 1983			ADCOM
Air Traffic Control	404L	TRACALS	Continuing Acquisition	1976-198[illegible]	SM-ALC (T&D, Operational)	Contractor to 1980	AFCC
		GPS-NAVSTAR	Test	Jun 1984	WR-ALC		TAC/SAC
	450A	LORAN C/D	Development and Acquisition	Jan 1981	SM-ALC (T&D, Operational)	Organic/SM-ALC	AFCC
Intelligence		IITS	Source Selection	UNK	TBD		TAC
	428A	TIPI	Development and Acquisition				TAC
		OASIS	Development and Acquisition		TAC/OC-ALC		USAFE
		BETA	Development and Acquisition	1980			TAC

Table 1-2. C-E Systems Operational Status (Concluded)

System	System No.	Short Title	Program Status	PMRT Date	Software Support Responsibility	Software Support Philosophy	User Command
Command and Control	416L	SAGE	Operational	1950's			NORAD
	416M	BUIC	Operational	1950's			NORAD
	465L	SACCS	Operational	1964	SAC	Organic	SAC
		NMCS	Operational				
		CCPDS	Design	1985			SAC
	427M	NORAD	Acquisition	Aug 1979	T&D/SM-ALC; Opnl/NORAD	Contractor	ADCOM
	407L	TACS	Operational	1974	T&D/SM-ALC; Opnl/TAC	Organic	TAC
	485L	TACSI	R&D and Acquisition	Jan 1983	T&D/SM-ALC; Opnl/TAC	Organic/Contractor	TAC
	411L	AWACS	Acquisition and Operational		T&D/Boeing; Opnl/TAC	Organic	TAC
	481B	AABCP	Development and Acquisition	1984			SAC
		SEEK SCORE	Development	Apr 1983	SM-ALC (T&D, Operational)	Organic	N/A
	AN/TSQ-96		Operational	1976	SM/ALC (Bomb Tape Only)	Organic	SAC
	AN/TPB-1C		Operational	1971	SM-ALC (T&D, Operational)	Contractor	SAC/TAC
		DTCS		Sep 1978	SM-ALC	Contractor	ADCOM
		PLSS	Engr. Development	Jun 1985	SM-ALC	Organic	TAC
Communications	490L	TDCS	Operational	Sep 1973	T&D/SM-ALC; Opnl-NCS/DCAOC	Organic	DCA/AFCC
		SCOPE SIGNAL	Acquisition	May 1982	T&D/SM-ALC; Opnl/AFCC		SAC
	1144	ATEC	Eng.Dev. and Production	Apr 1985	SM-ALC/AFCS	Organic	AFCC
	2206	DEB	Validation and Acquisition				
	1205	AFSATCOM	Development and Acquisition	Oct 1980	T&D/WR-ALC	Organic (SAC)	SAC/AFCC
	1136	SACDIN	Development	Jan 1984	T&D/SM-ALC; Opnl/SAC	Organic (SAC)	SAC
	478T	CTC-TCCF	Development and Acquisition	Apr 1984	T&D/SM-ALC; Opnl/AFCS	Organic (AFCS?)	AFCC/TAC
	2283	JTIDS	Engineering Development		WR-ALC		TAC
		EC-135	Operational		SAC/WR-ALC		SAC
Meteorological		AWDS		1985	TBD		MAC/AWS
		WSC		1981	SM-ALC	SM-ALC	MAC/AWS

2. C-E CATEGORY ECS SUPPORT REQUIREMENTS

This section identifies a set of nineteen generic support requirements along with several additional requirements that are unique to the C-E category of ECS. The first nineteen requirements are defined as "generic" because they are essentially a common set of requirements that apply to each ECS category (OFP, ATD, EW, and ATE) as well as to the C-E category. The C-E "unique" requirements stem mainly from the fact that certain C-E systems are supported either partially or totally by the user of the system, i.e., the operational command. For the most part, such a sharing of support responsibility is a situation that exists mostly within the C-E category.

The generic requirements have been grouped into the following six functional areas: (1) ECS Change, (2) Change Analysis and Specification, (3) Engineering Development and Unit Test, (4) System Integration and Test, (5) Change Documentation, and (6) Certification and Distribution. Sections 2.1 through 2.6 provide a short discussion of each of the nineteen requirements, while Section 2.7 discusses the unique requirements. Table 2-1 presents a brief summary of each support requirement.

2.1 ECS CHANGE

Requests for changes to the computer programs resident in a weapon systems ECS can stem from the operational user for one of several reasons. During system operation, degraded or improper system performance may lead to the discovery of a software computer program design error (Class I) of perhaps a less serious problem such as a minor software malfunction or discrepancy (Class II). Additionally, a software change may be required to implement an enhancement in the system or to update it from new intelligence information. For example,

Table 2-1. C-E System Support Requirements

C-E Change Requirement	Remarks
ECS Change	
• Receive and process requests	• Change requests can originate from a number of sources and can range in importance from emergency/urgent to desired or nice to have. Procedures are required to record and track all change requests.
• Preliminary analysis and problem/deficiency definition	• This activity can be accomplished in varying degrees by the requestor and the supporter depending upon the nature of the problem and the knowledge and tools available.
• Preliminary resource allocation and scheduling	• Involves priorities and coordination with user and sources of support depending upon nature and number of changes.
Change Analysis and Specification	
• Feasibility	• Can the change be accomplished? If not, why? If yes, what is the approach to the solution? What are the likely software, hardware, and system impacts?
• Requirements decomposition/definition	• The selected design approach is examined and resource requirements are further detailed.
• Preliminary design	• Preliminary design and testing approach is established. Technical conferences and Preliminary Design Reviews (PDR's) are held.
• Detailed design	• Design approach is finalized; specification, test procedures, and development plans are prepared/updated. Critical Design Reviews (CDR's) are held.
• Generate change proposal	• Document results of technical evaluation and analysis, generate and distribute the Computer Program Change Proposal (CPCI).

Table 2-1. C-E System Support Requirements (Continued)

C-E Change Requirement	Remarks
Engineering Development and Unit Test	
• Develop the change	• Implement the design, coding of computer program changes, establish new C-E baseline, coordinate if also a hardware change.
• Perform engineering tests	• Module/code level testing, create a new compiled program.
System Integration and Test	
• Test ECS system performance	• Ensure that as-coded change satisfied requirements and has no adverse effects on the operation of the unchanged parts of the ECS software programs.
• Test weapon system performance	• Ensure that change or changes satisfy system requirements without adverse affect; includes *flight test depending* upon nature of change.
• Produce test reports	• Analysis of simulation/flight test and documentation of results.
Change Documentation	
• Document ECS change	• Update specific change in all working documents.
• Update ECS baseline	• Update ECS specifications and support system specification as necessary.
• Configuration control	• Establish new baselines for formal control.
Certification and Distribution	
• Certify documentation	• Administrative sell-off/buy-off.
• Distribute revised ECS data	• Prepare and coordinate technical publications.
• Provide installation procedures/ instructions	• Participate in installation of change.

Table 2-1. C-E System Support Requirements (Concluded)

C-E Change Requirement	Remarks
Unique Requirements	
• **Shared software support**	• **Systems such as the E-3A AWACS and JTIDS, which are supported in part by TAC and in part by AFLC, require more complicated configuration management procedures than would otherwise be required.** • **JTIDS' support posture includes, in effect, a distributed ISF. Each of the three facilities require a technically correct interface.** • **The TAC E-3A ISF at Tinker AFB and the OC/ALC ISF will both share the IBM 370/155. Mutual operation of a single computer must be coordinated.** • **Inter-command working relationships must be established to facilitate coordination activities.**
• **Intelligence support**	• **SIMVAL and C^3CM programs will require access to classified data bases.** • **Special work areas and personnel access control will have to be established.**

if a new improved radar were to be substituted for an older radar in a S&W system substantial changes could be required in the ECS software package. On the other hand new intelligence may require a change in ECS software associated with countermeasures applications.

2.1.1 Receive and Process Requests

ECS software change requests are expected to be generated, for the most part, by the system's user in response to newly discovered software errors that create a software deficiency, new intelligence data effecting system performance or in response to technology improvements that can enhance the system capability if implemented. These formal ECS change requests are prepared, forwarded to the proper ALC, received and recorded by the ALC, and entered into the change request processing chain.

2.1.2 Preliminary Analysis and Problem/Deficiency Definition

The first step in processing the change request is to conduct a preliminary analysis to categorize the request (system deficiency, user enhancement, etc.) and to determine general feasibility of implementing the request. The request should be compared to previous requests to ensure its uniqueness. It may be advisable to append it to a previous request that addresses a closely related problem. In either case, a carefully worded technical statement of the change request is prepared for further processing.

2.1.3 Preliminary Resource Allocation and Scheduling

The integration support facility must estimate the resources, considering organic and contractor resources, which are required to effect the requested change. The required resources are then allocated and the activity is integrated into the center's overall workload. It may be necessary to substantially revise the overall schedule to accommodate a high-priority change request. For less than high-priority requests it may be advisable to delay processing of the request until several low-priority requests can be processed in a block mode in a single change cycle.

The block change mode of change control is an economical method of making small changes in a relatively dynamic system, however, many C-E systems do not require periodic changes. On the other hand, some systems will require numerous mission oriented software changes on a priority basis. Specific procedures for each system should be provided in resource planning and configuration management documents, such as the CRISP and O/S CMP.

2.2 CHANGE ANALYSIS AND SPECIFICATION

To this point in the process the request change has been only broadly identified and scoped with an estimated completion date established. Prior to initiating actual development and integration, it is necessary to examine alternative approaches with respect to such parameters as cost, impact on the ECS and the overall weapon system in terms of performance, and overall feasibility. Given a feasible solution is found, the support center team will develop a design and generate a Computer Program Change Proposal (CPCP) for management approval.

2.2.1 Feasibility

Alternate approaches are conceptualized and examined to establish their feasibility to implement the requested change. The approach that offers the most timely cost-effective solution is selected.

2.2.2 Requirements Decomposition/Definition

Based on the selected design approach, the overall technical activity is decomposed into subtasks that are of a manageable size. A Work Breakdown Structure (WBS) approach is used to organize the overall technical task. This WBS also will guide development of the subtasks work package writeups that will direct the work package manager.

2.2.3 Preliminary Design

A preliminary design, based on the previously selected design concept, is prepared for review at a Preliminary Design Review (PDR). This design should be sufficiently detailed so as to allow its reviewers to approve it for further design efforts.

2.2.4 Detailed Design

The approved preliminary design is expanded in scope and detail to produce a detailed analytical design from which detailed software specifications can be written. Test procedures must also be specified to allow subsequent development of a detailed test plan. A Critical Design Review (CDR) will be held to confirm that the design meets its development requirements.

2.2.5 Generate Change Proposal

The Computer Program Change Proposal (CPCP) is the technical description of the work to be performed. It will serve as the basis for reaching an agreement with the requester as to the adequacy of the solution and as the basis for obtaining management approval prior to entering the development and integration phases of the change process. Management approval will be from either a Computer Program Configuration Sub-board (CPCSB) or a Configuration Control Board (CCB).

2.3 ENGINEERING DEVELOPMENT AND UNIT TEST

When the detailed design presented in the change proposal has been approved, the next step in the change process is to initiate the efforts to develop and test the necessary changes.

2.3.1 Develop the Change

The project team implements the changes by preparing the new software code for all the affected software modules within the overall software program. If any hardware changes are required, all interfaces must be coordinated with the hardware change engineers.

2.3.2 Perform Engineering Tests

As the new code for each module is prepared it is necessary to conduct unit or module testing to ensure the validity of the software changes. These tests need only be designed to test one module at a time.

2.4 SYSTEM INTEGRATION AND TEST

After the module level changes have been implemented and tested it is necessary to reassemble the ECS software and perform ECS level and weapon system level testing.

2.4.1 Test ECS System Performance

Changes to the ECS must be tested with the ECS viewed as a subsystem prior to integration and test of the total weapon system. It may be necessary to provide an input scenario and simulations of the other components of the weapon system to successfully test the ECS as an independent subsystem.

2.4.2 Test Weapon System Performance

After the ECS has been successfully tested as an independent subsystem it can be integrated into the total weapon system. The total system is then tested to demonstrate that the desired system performance improvements have been attained. These system level tests may involve actual aircraft flight tests for airborne systems or the flying of aircraft against ground based systems. This level of testing requires user involvement. In other cases, the use of a simulator may be necessary, for example, to simulate missile launches when testing an S&W weapon system.

2.4.3 Produce Test Reports

As the testing progresses it is necessary to compile the results of individual and collective tests. Good engineering practice dictates that all testing efforts should rigorously follow the test plan and that all test results be carefully recorded. The test results are then collected and published in the final test report. It is only after approval of the final test report that request changes can be implemented in fielded weapon systems.

2.5 CHANGE DOCUMENTATION

All implemented changes, minor or major, must be reflected in the system's documentation. This documentation may exist in the form of operators manuals, programmers manuals, technical manuals

and so forth. For many systems the baseline computer program(s) may exist on magnetic tape or disc storage media. In any case, all relevant documentation must reflect the current configuration of the system.

2.5.1 Document ECS Change

All working documents, in whatever form, must be updated to reflect the changes in the system. Inadequate or, worse yet, incorrect documentation can lead to severe problems when attempts are made in the future to respond to requests for software changes.

2.5.2 Update ECS Baseline

The ECS baseline must be updated in whatever form it exists. This can include system specifications, magnetic tapes, hardware drawings and so forth. All baseline data must be maintained current.

2.5.3 Configuration Control

Good engineering practice requires that all system documentation be under configuration control. The implementation of configuration control procedures is especially important in the final stages of integration and test so that system failures will not offset progress made prior to the most recent benchmark.

2.6 CERTIFICATION AND DISTRIBUTION

A central point should exist within the office of the System Manager (SM) who has the authority to certify the technical adequacy of the change and order its implementation in all fielded systems.

2.6.1 Certify Documentation

Assuming that all system testing has been successfully completed and all system documentation accurately updated, it is the SM's responsibility to certify that the change action is complete.

2.6.2 Distribute Revised ECS Data

Revised baselines are now available for installation in all fielded systems. A distribution process is initiated which ensures that revised capabilities and revised documentation is available to the user.

2.6.3 Provide Installation/Procedures/Instructions

The user may install the changes provided adequate procedures and instructions are available to describe the installation. Certain updates may require specialized personnel and/or procedures which are not within the user capability, and thus must be otherwise arranged.

2.7 UNIQUE C-E SUPPORT REQUIREMENTS

Many C-E systems, perhaps even most, are deployed in relatively small numbers. For example, COBRA JUDY will have one site, PAVE PAWS has only two, JSS is to have seven, and SEEK IGLOO will have a total of thirteen. In this context these total numbers are small when compared to the number of OFP's supported in fighter aircraft programs (F-15/729, F-16/1388).

Regardless of the number of systems to be supported the most important factors in determining ECS support requirements are frequency and complexity of change. For example, it is possible that an ECS change for 2000 aircraft may consume fewer resources than a single PAVE PAWS change. The decision to build a centralized ISF or use a field site to support the ECS software must be made in light of operational requirements, frequency of change, number of configurations to be supported, and available common resources.

Each case is decided on a system-by-system basis with a Memorandum of Agreement (MOA) spelling out the details of each command's responsibilities. In addition to the MOA, the CRISP and the O/S CMP further define intercommand responsibilities and interface relationships.

It should be noted here, even though the user may be providing partial or even total support for the system's ECS software, that the SM retains responsibility for overall system support. This places the SM in a situation where discharge of his system responsibilities requires a close working relationship with other supporting agencies. In the future this could include coordination with intelligence collection and dissemination organizations.

2.7.1 Operational Support Scenarios

The user is often totally or partially responsible for providing the capability to support the system's ECS software. The spectrum of AFLC support, in the face of this potential variation in user support, can be described by defining three different support scenarios.

In the first case, AFLC has responsibility for all software support. In this situation, the assigned ALC will provide the capability to support the totality of the system's operational, support, and test software. An example of such a case is the TRACALS TPN-19/GPN-24 ECS which is to be supported by the SM-ALC.

In the second case, AFLC shares the responsibility for software support with the operational command. In this situation, the degree of sharing is decided on a system-by-system basis, based on the user's desire to control operational software associated CPCI's. AFLC would then typically be responsible for the support software and the test software CPCI's. An example of this apportionment is illustrated by the E-3A AWACS program. TAC has responsibility for ten E-3A CPCI's which are closely related to command and control functions, while AFLC has responsibility for the six remaining E-3A CPCI's.

In the third case, AFLC's system manager retains system support responsibility with the CPCI support responsibility assumed by the user command. In this situation, the user command must provide the capability to support all of the ECS's CPCI's. An example of this situation is the Joint Surveillance System (JSS). AFLC ECS support will be limited to producing PROM's for diagnostic software.

2.7.2 Support Management

Each new entry of a C-E system into the acquisition process presents AFLC with a requirement to establish a support team to fulfill the commands' support responsibilities during the pre-PMRT and the post-PMRT time periods. Support responsibilities during the pre-PMRT time period relate mainly to monitoring system development to ensure system supportability after "transition" to AFLC. Post-PMRT responsibilities will incorporate the complete spectrum of traditional support for all elements of the system and are dependent upon the support arrangements delineated in the MOA, the CRISP, and the O/S CMP.

These responsibilities can be categorized under the functional headings of (1) system management, (2) system engineering, (3) hardware engineering, and (4) software engineering. AFLC assigns the system support responsibility to a specific ALC and then from within the ALC's functional organizations, personnel are designed to fill the roles of System Manager (SM), System Engineer (SE), hardware engineer, and software engineer.

The responsibilities of these key management and engineering personnel, at any point in time throughout the system's life cycle, will reflect the specific phase in the system's life and other system-related factors such as system size, complexity, mission, and so forth.

Section 2.7.1 defined three support scenarios that differ in the degree of sharing of the software support responsibility with the system's user. On the surface it would appear AFLC's involvement would decrease as the user assumed more ECS software responsibilities; however, this is not the case. The ALC system manager still retains configuration responsibilities whether the change is software or hardware. In many cases a software change made by an operational user will impact systems performance or exacerbate configuration management problems. Both hardware and software changes call for action by

the SM. For example, software changes made by operational users could impact system memory allocation or conflict with AFLC planned use of growth memory space. In real time systems, added user functions can slow CPU throughout, thereby impacting other software functions. When user changes are implemented in ROM's or PROM's the configuration management problem grows rapidly with each new configuration. If the change impacts PROM's on more than one PC board within the same black box then the configuration problem increases by a significant factor, depending on the number of PC boards involved. Additionally, when an ECS software change does not meet user expectations, both the hardware and software engineer must work in concert to determine the cuase and find a solution. This integrated capacity is often lost when the user is totally responsible for ECS software changes with the ALC responsible for the hardware changes. If both commands share responsibility for software support, the configuration management of the system becomes a difficult if not impossible task.

Some systems, due to operational requirements, must be supported by a software support facility under the user's control. In most cases, however, these facilities lack the integration support capabilities of an ISF.

2.7.3 Intelligence Support

There is a growing trend to use embedded computers to give weapon systems a rapid configuration change capability. In the past the need for rapid changes in ECS software was limited to EW and ATD systems. However, the introduction of the Command Control Communication Countermeasures (C^3CM) programs will generate new ECS software change requirements, in addition to generating a host of new support problems. Most of the data needed to make C^3CM ECS software changes is classified secret or higher. In some case the supporting and background data required by the decision making process (technical assessments) is often top secret and sometimes requires compartmented access. Data at these higher classifications will require specialized handling facilities and specially cleared technical staffs to work on specific aspects of the ECS software change.

The full scope of the C^3CM mission is by its very nature classified and at this time is undergoing numerous changes as responsible agencies define their roles. Once these missions are fully defined, AFLC's involvement can be fully assessed. However, as a support command AFLC's involvement could be significant.

This direct involvement in updating C^3CM software will require access to classified intelligence data bases and the use of computerized retrieval system as well as classified storage and work areas. In addition, individuals selected to work on classified projects must have the proper security clearance and, in some cases, special access billets. The total number of special access billets required will depend on the number of systems supported and specific C^3CM requirements. Initially, only a relatively small number of special access billets should be required.

3. C-E CATEGORY ECS SUPPORT CONCEPTS

3.1 INTRODUCTION

This section describes the software support concepts that are in place or undergoing development by several USAF MAJCOM's. AFLC, as the primary support command, will provide support for many C-E systems; however, several user commands will be responsible for supporting at least a portion of the ECS software in selected C-E systems. These commands include ADCOM, TAC, SAC, and AFCC as well as AFLC. These command-specific concepts are included in Section 3.2.

Section 3.3 presents an overview of the specific organizations within the MAJCOM's that have software support responsibilities. The section also indicates when coordination interfaces are required and identifies the participants on each side of the interface.

Section 3.4 is included to describe the overall management philosophy being adopted by AFLC for supporting C-E systems. The section includes a general description of the concept of operation and, in addition, a more detailed definition of the roles and responsibilities of the systems manager, systems engineer, and the hardware and software engineers.

Section 3.5 presents a brief description of the hardware maintenance philosophy that supports the hardware elements of embedded computer systems.

3.2 C-E CHANGE CONCEPT/PROCESS

Within the USAF the AFLC is the command having prime responsibility for weapon system logistics support including software support for those weapon systems having embedded computers. However, there are some exceptions to this assignment of responsibility. Certain systems, particularly some of the C-E systems, have software support

provided in part or in whole by a command other than AFLC. For example, TAC, SAC, AFCC, and the former ADCOM (now ADTAC and ADSAC) are the operational users of several C-E systems for which they provide significant amounts of software support. Each of these commands has developed its own similar, but not identical, concept for providing the requisite software support. The following sections will describe the software support concept as practiced by each command.† The specific configuration control concepts employed by the individual commands are derived from the policy expressed in AFR 800-14 Volume I, Management of Computer Resources in Systems; and Volume II, Acquisition and Support Procedures for Computer Resources in Systems. Volume I establishes policy for the acquisition and support of computer equipment and computer programs employed as dedicated elements, subsystems, or components of systems. Volume II consolidates procedures that apply when implementing the policies of AFR 800-14, Volume I and other related publications as they pertain to the acquisition and support of computer resources. It applies to all activities responsible for planning, developing, acquiring, supporting, and using computer resources in systems.

- AFLC concept - specific AFLC policy has been published in AFLCR 800-21, Management and Support Procedures for Computer Resources used in Defense Systems. This regulation expands and carries out the policies of AFR 800-14, Volumes I and II and other related directives as they pertain to the role of AFLC in support of defense systems and support systems computer resources. It applies to all AFLC field units responsible for planning, developing, acquiring, modifying, reprogramming, and using computer resources.

† Note: The reallocation of ADCOM responsibilities between ADTAC and ADSAC is currently underway. In lieu of specific ADTAC and ADSAC ECS policies, ADCOM policies are presented and discussed under the assumption these policies will be sustained in SAC/TAC regulations and directives.

- <u>ADCOM concept</u> - specific ADCOM policy has been published in ADCOMR 55-111, Configuration Management for Operational ADCOM Space Defense System Computer Programs. This regulation establishes the configuration management concept for operational space defense system computer programs for which ADCOM has configuration management responsibilities. These systems include those used for space surveillance, missile warning, and related command control communications. This regulation implements portions of AFR 800-14 and is directive upon all ADCOM units which operate or support space defense systems. It will also be used as a guide by all agencies supporting ADCOM requirements.

- <u>TAC concept</u> - specific TAC policy has been published in TACR 171-24, TAF Configuration Management System. This regulation establishes a configuration management system and a governing Tactical Air Forces Configuration Management Board (TAF/CMB) to ensure interoperability of interfaces among command and control, weapons and intelligence systems of the Tactical Air Forces. It also establishes the Interface Standards Subgroup (ISS) and the Tactical Systems Interoperability and Support Center (TSISC) to provide technical and test assistance to the TAF CMB.

- <u>SAC concept</u> - SAC's approach to providing C-E computer resource support is to follow the provisions of the applicable Air Force series of regulations i.e., AFR 300 or AFR 800. The 300 series is used primarily to manage the large scale command and control systems, such as the SACCS, AABCP and CCPDS. Those C-E systems associated with or integrated into aircraft systems follow the provisions of AFR 800-14 and applicable SACR 55-XX regulations.

  Following the guidance in AFR 800-14, SAC supports the applicable computer resources working groups and participates in the development of CRISP's and O/S CMP's. When operational requirements indicate the need for rapid reprogramming of operational software, SAC assumes management responsibility for portions of the software.

- <u>AFCC concept</u> - AFCC has not supplemented Air Force ECS support policy and procedures as contained in AFR 800-14. AFCC views its primary ECS role as supporting the operational users. In this role, AFCC representatives

actively participate in the preparation of CRISP and O/S CMP's. Once these documents are written, coordinated, and signed they serve as the basic support agreement, unless unusual circumstances require separate MOU's or MOA's.

Finally, it should be noted that for those C-E systems wherein software support responsibility is shared by AFLC with another command (for example, E-3A AWACS), a Memorandum of Agreement (MOA) is developed that identifies the specific CPCI's that are to be supported by each commad. The CRISP and the O/S CMP will provide added information relative to inter-command interface procedures and the like.

3.2.1 AFLC Support Concept

AFLC's generic approach to providing computer resource support to those C-E system CPCI's for which AFLC is responsible is described in this section. The configuration management procedures outlined below stem from the guidance of AFR 800-14 and AFLCR 800-21. These procedures will be followed regardless of whether AFLC is solely responsible for the system's software support or shares the support with the user command. However, when the support is shared, there will be an increase in inter-command coordination to ensure that software changes made by AFLC do not impact the CPCI's supported by the user.

The key features of the support concept include the establishment of a Change Control Board (CCB) and a Computer Program Configuration Sub-Board (CPCSB). The CCB is the senior board and has primary responsibility for all software and hardware changes to the ECS. The CPCSB is subordinate to the CCB but nonetheless it has final approval for all pure software changes. If a software change affects hardware or a change is desired that affects both software and hardware, the approval must come from the CCB. In addition to the CCB and CPCSB, a screening panel is established. This panel will conduct a preliminary screening of all change, enhancement, or modification requests to determine whether hardware, software, firmware, and/or documentation impacts are involved. Similarly, the impacted baseline(s) would be identified.

CPCI changes are categorized as either Class I or Class II changes. A Class I change is defined as a "design" change while a Class II change is defined as a "discrepancy" change.

The change process is initiated when a user submits a Material Deficiency Report (MDR) prepared on DD Form 173, Joint Message Form. The basic information required and the format used to report the deficiency is contained in T.O. 00-35D-54.

Upon receipt of the MDR at the appropriate ALC the SM will have the screening panel review the report for completion of information and initiate validation. The panel will make an initial determination as to the impact on hardware and software. Depending upon the initial assumptions made in the problem definition, the MDR may follow one of three paths; i.e., hardware only, software only, or both. In addition, the screening panel will determine the CPCI change classification such as design (Class I) or discrepancy (Class II). Class II changes that are approved for action will go to the appropriate action agency for resolution; if the change is disapproved it will be returned to the initiator. If the problem is determined to be a Class I change or if no approval/disapproval is taken for Class II changes, the screening panel will forward the change to the CPCSB for resolution.

The CPCSB will review the MDR proposed change and take action in accordance with established procedures. These procedures are usually documented in the system's O/S CMP. Approved changes will be distributed to the proper action agencies for resolution.

After approval by either the CCB or the CPCSB a change proposal will be prepared to guide the implementation of the change.

When the software code has been revised, the change must be integrated and tested. The extent of integration and system level versus component level testing will be a function of the capabilities of the ISF

in which the change is being implemented. ISF capabilities may range from simple reprogramming facilities, to more complex facilities capable of integration and testing at the ECS level, to extensive facilities with "hot mockup" components that allow full verification and validation of the software and/or hardware change.

In many cases, the distribution of the change to affected field sites will use the Time Compliance Technical Order (TCTO); however, this format may be modified to meet the unique requirement of CPCI change distribution.

Figure 3-1 illustrates a general flow through the change process from the receipt of an MDR to the distribution of the validated change to the users. This figure which was initially prepared by SM-ALC (MMEC) represents a generic change concept/process. Even though it is described as a generic process, it is planned that each C-E system specific process to be implemented at SM-ALC will be based on this activity flow.

3.2.2 ADCOM Support Concept

ADCOM's generic approach to providing computer resource support to those C-E system CPCI's for which ADCOM is responsible is described in this section. The configuration management procedures outlined below stem from the guidance of AFR 800-14 and ADCOMR 55-111. As will be seen, ADCOM's software change process is very similar to that employed by AFLC.

One significant difference, however, between AFLC's and ADCOM's support posture relates to the location of the system's ISF. For AFLC, the individual system's ISF is usually to be located at the responsible ALC facility. For example, the TRACALS and SEEK IGLOO ISF's are both to be located at SM-ALC. For ADCOM, the ISF is usually located at one of the operating sites. For example, the JSS ISF is located at

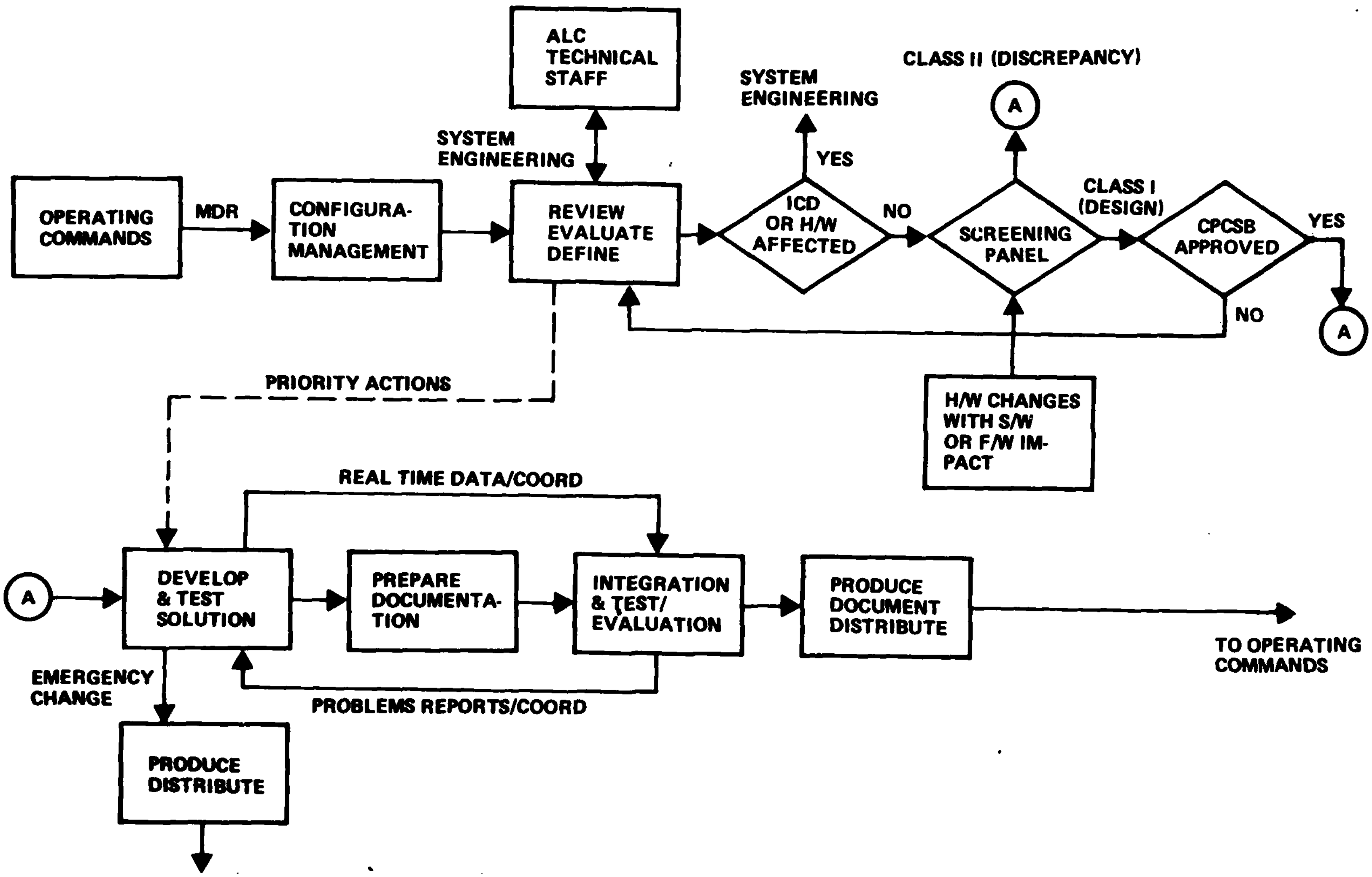


Figure 3-1. AFLC C-E Software Change Process

the JSS Region Operation Control Center (ROCC) at Tyndall AFB, FL. The JSS support facility is actually called an ROCC Software Support Facility (RSSF) instead of an ISF; however, one of its three missions is to provide a means for implementing CPCI changes.

The key features of the ADCOM support concept include the establishment of a Configuration Review Board (CRB) and a Computer Program Configuration Management Board (CPCMB) for each system ADCOM is to support. These two boards perform essentially identical functions to the CCB and CPCSB established by AFLC to support their assigned C-E systems.

The ADCOM CPCMB is established to review and recommend to HQ ADCOM/DOP the deferral, approval, or disapproval of proposed modifications to the configuration of operational space defense system CPCI's. Board recommendations will be a majority vote of the members, with dissensions reported to the approval authority (HQ ADCOM/DOP). HQ ADCOM/DOP may delegate approval authority to the CRB for changes to off-line application programs. This delegation may be for specific programs, specific types of programs, or for all off-line programs. CPCMB meeting minutes, when approved, become the official record and authority for the Systems Programming Agency (SPA) to proceed with implementing the approved changes.

For ADCOM C-E systems having only one site (e.g., FPS-85, FPS-108), the CRB is established at the site. For multi-site systems, a Site Configuration Review Board (SCRB) is established at a site that has a computer programming capability. In either case the functions of the board are basically the same.

Figure 3-2 illustrates the general flow through the ADCOM CPCI change process from the preparation of a Program Modification Request (PMR) or a Program Change Document (PCD) to the receipt by the requester of a revised CPCI that has been fully tested and is ready for operational use.

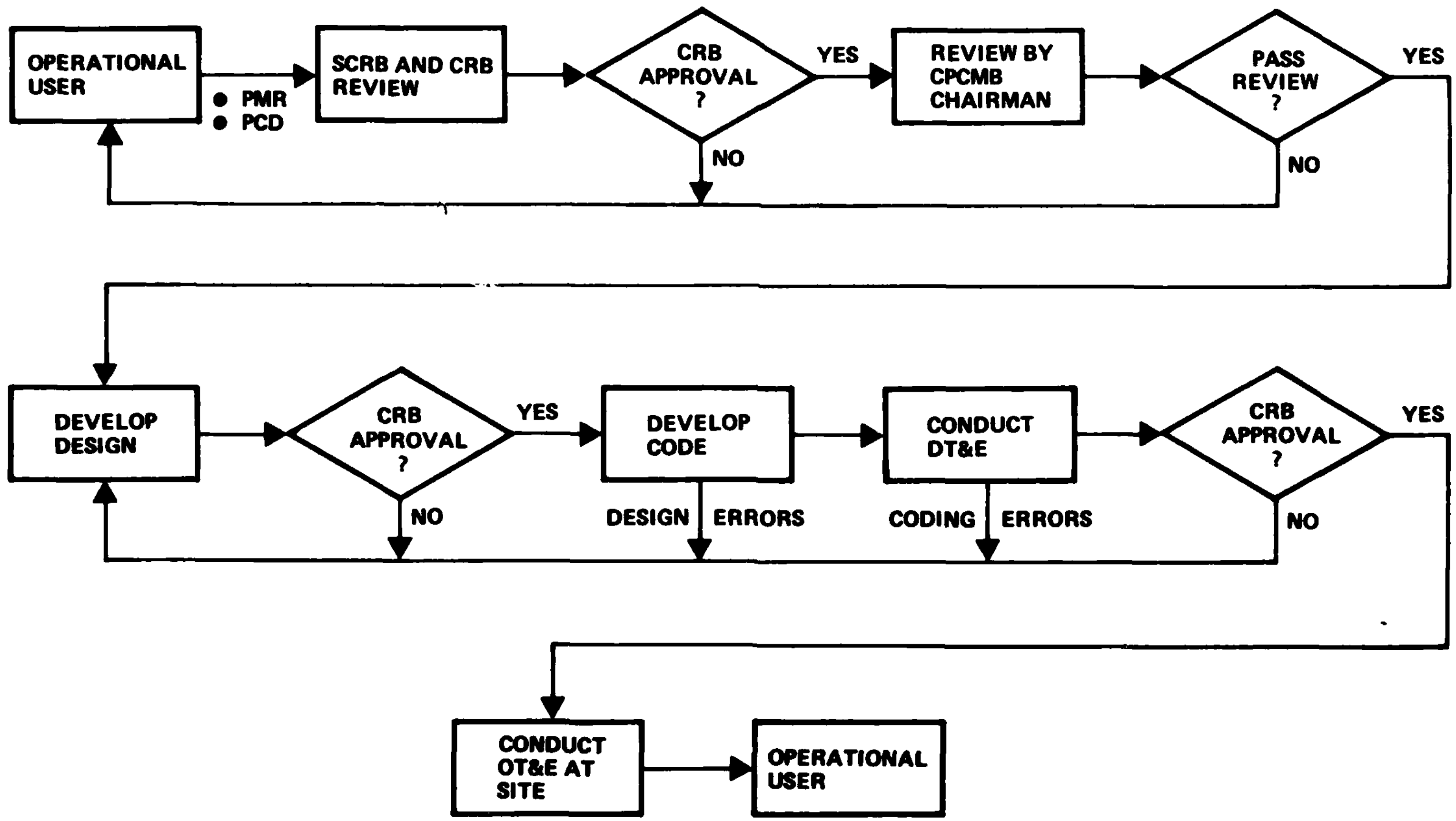


Figure 3-2. ADCOM C-E Software Change Process

ADCOM Form 542, Program Modification Request (PMR), may be submitted by any system user to HQ ADCOM/DOPP. Because the PMR is used to request software design changes (i.e., a Class I change), a change to the CPCI Part I Specification will normally be required. If possible, the originating agency should prepare this change, using a Program Documentation Discrepancy Report (PDDR) as a cover sheet.

ADCOM Form 549, Program Change Document (PCD) may be submitted by any user to HQ ADCOM/DOPP. Because the PCD is used to report software program malfunction/discrepancy problems (i.e., Class II changes), a change to the CPCI Part II Specification will normally be required. If possible, the originating agency should prepare the change using a PDPR as a cover sheet.

The CRB will ensure that all PMR's and PCD's have Part I or Part II Specification PDDR's attached, if required, before they are sent to HQ ADCOM for approval. SCRB's at each site and the CRB will critically examine and evaluate all PMR's and PCD's, ensure they contain proper justification, and make recommendations to the ADCOM CPCMB. When a PMR or a PCD arrives at HQ ADCOM, the CPCMB chairperson may either return it to the originator for more information or schedule it for CPCMB action.

CPCI changes, both PMR and PCD types, are generally scheduled for inclusion in periodic version releases (with the concurrence of operational sites). The frequency of those releases will depend on the number and magnitude of outstanding PMR's or PCD's, available manpower, and available computer time. When the CRB has determined which PMR's will be included in a version, they will prepare a final change to the Part I Specification to establish the allocated baseline. For long term projects, the CRB may authorize design and code work to start before a PMR is allocated to a specific version. Version production consists of three distinct phases: design, code, and test (with possible iterations if design errors are discovered while coding is in progress or if design or code errors are discovered during testing).

When a version has been built and has successfully completed Development Test and Evaluation (DT&E), the CRB will complte ADCOM Form 540. Version Release Request, listing all PMR's and PCD's in the version. The CRB chairman will sign the ADCOM Form 540, authorizing delivery of the version to operational sites. The CRB will then send a copy of the signed ADCOM Form 540 (along with the DT&E Test Plan and Test Report, and a Version Description Document) to HQ ADCOM/DOPP and the system OPR. The site staff with SPA assistance, will develop OT&E procedures to assure the new version meets operational requirements and conduct the OT&E. Following the site OT&E, the site operations officer will authorize use of the new version, informing HQ ADCOM/DOPP and other interested agencies by message.

Special processing procedures are required for selected CPCI's used by ADCOM space defense systems. These are CPCI's that are under configuration management of more than one command. Certain commercial, executive, supervisory, and maintenance/diagnostic software is under the configuration management of AFLC's Sacramento Air Logistics Center (SM-ALC). The System Programming Agency (SPA) may tailor this software for a specific site or system. Tailoring includes deciding which modules will be core resident and which will reside on auxiliary storage, changing device address tables, changing trace table lengths, and the equivalent. The SPA will advise HQ ADCOM/DOPP of these changes in writing, and DOPP will inform SM-ALC/MMC. If code changes are required, the SPA will submit a PMR (filled out as completely as possible) to HQ ADCOM/DOPP, who will forward it to SM-ALC for action. HQ ADCOM/DOPP will be responsible for status accounting of PMR's sent to SM-ALC until they are either installed or returned to an SPA for development.

3.2.3 TAC Support Concept

TAC's generic approach to providing computer resource support to those C-E system CPCI's for which TAC is responsible is described

in this section. The configuration management procedures outlined below stem from the guidance of AFR 800-14 and TACR 171-24.

To help fulfill their responsibility the command has established a configuration management system and a Tactical Air Force Configuration Management Board (TAF/CMB) to ensure operability of interfaces among command and control, weapons, and intelligence systems of Tactical Air Forces. TAC has also established an Interface Standards Subgroup (ISS) and a Tactical Systems Interoperability and Support Center (TSISC) to provide technical and test assistance to the TAC/CMB.

Figure 3-3 is presented to show the relationships among the CM groups. The figure indicates that it is the Joint Standards Group for Tactical C^3 Systems (JSG/TACCCS) in the office of the Joint Chiefs of Staff (JCS) that sets the interoperability standards control for the CMB and all TAC C-E system CPCSB's. The figure also indicates that the working interface with AFLC and other commands is implemented via their participation in ISS functions. The following paragraphs briefly describe the role of each of the key groups of Figure 3-3.

The governing body for the TAF configuration management system is the TAF Configuration Management Board (TAF/CMB), chaired by HQ TAC, assistant DCS operations for control and support, who has overall responsibility for the decisions of the TAF/CMB. Membership consists of the chairpersons of the individual tactical C^2I system Computer Program Configuration Sub-Boards (CPCSB's) and a representative from both USAFE and PACAF. At meetings of the TAF/CMB each member is prepared to provide impact statements and/or feasibility studies on each proposed change including a recommendation on whether or not the proposal should be implemented. Decisions of the TAF/CMB are based on a majority vote of the members. Decisions are recorded in the TAF/CMB minutes and are formalized by the chairperson signing the minutes. The members' official positions of

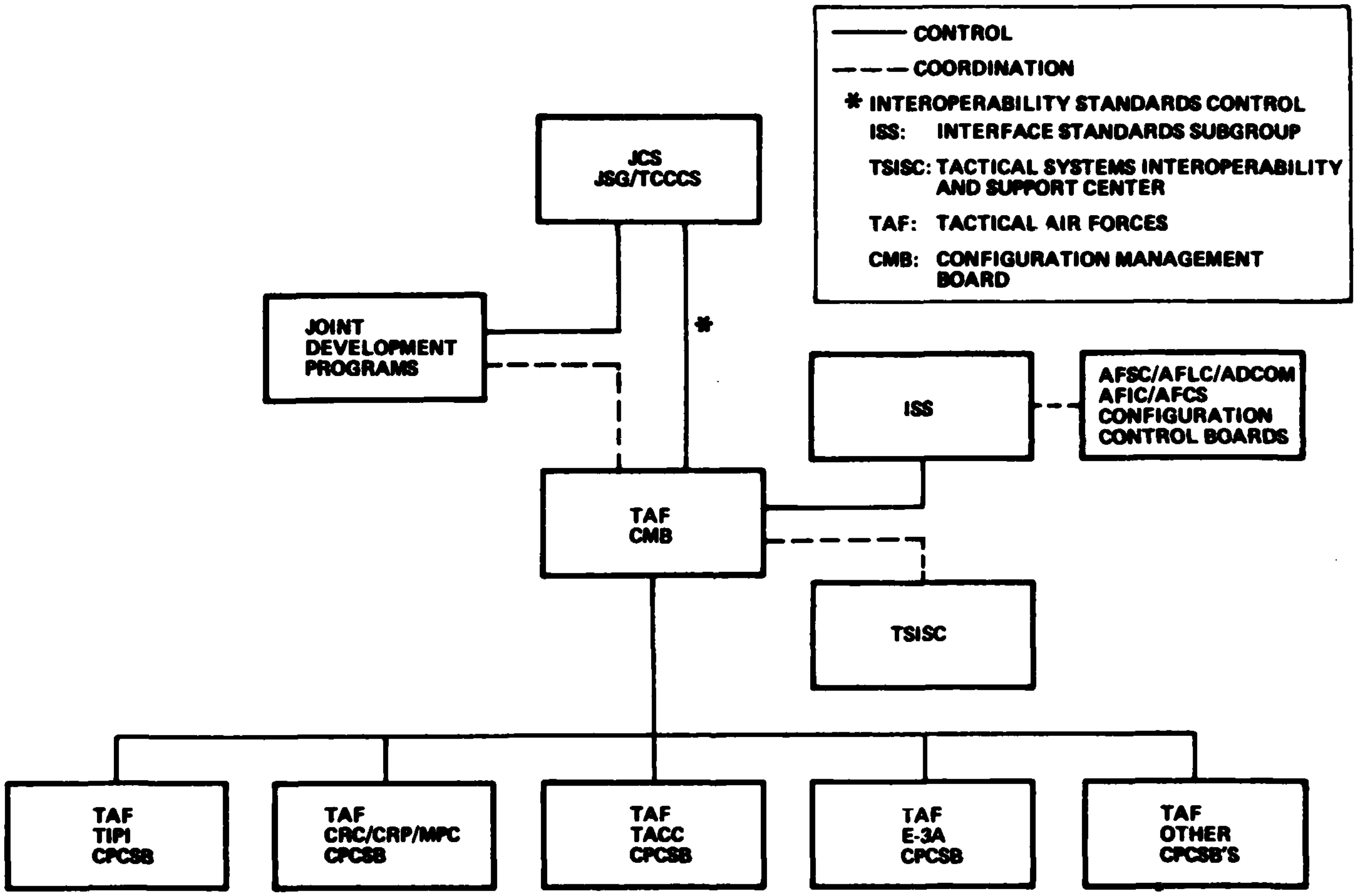


Figure 3-3. TAF Configuration Management Relationships

concurrence or non-concurrence are recorded in the minutes. The TAF/CMB is assisted by the Tactical Air Forces Interoperability Group (TAFIG), and Tactical Systems Interoperability and Support Center (TSISC), and the HQ TAC staff elements responsible for operational and developmental tactical C^2I systems. The TAF/CMB, with subgroups designated as required, performs configuration management in accordance with pertinent directives.

The Interface Standards Subgroup (ISS) of the TAF/CMB is chaired by TAFIG and is composed of representatives from the TAFIG, the TSISC, and from each of the TAF Computer Program Configuration Sub-Boards (CPCSB's). The chairperson of the ISS also functions as the Executive Secretary of the TAF/CMB. For those systems and programs which have not been turned over to TAC, TAF representatives to the respective developing agency configuration control boards also participate in the ISS. The Air Force Systems Command (AFSC), the Aerospace Defense Command (ADCOM), the Air Force Logistics Command (AFLC), the Air Force Communications Command (AFCC), and the Air Force Intelligence Center (AFIC) are invited to observe or participate in the functions of the ISS as appropriate. ISS membership includes personnel with both operational and technical backgrounds which enables them to thoroughly discuss recommended interface changes and to perform a detailed assessment of the impact of the proposed changes on any of the involved systems.

Testing of the TAF systems is accomplished by the Tactical Systems Interoperability and Support Center (TSISC). The TSISC performs interoperability testing between TAF systems and other service systems. The TSISC is administered by the Tactical Systems Interoperability and Support Division (HQ TAC/ADYC) within the TAC Office of Data Automation.

Within the TAF, a CPCSB is formed for each C^3I system to provide standardization and configuration management for its respective computer programs, as defined in AFR 800-14, and prescribed in associated agreements/procedures.

Configuration control procedures within TAC for implementing a software CPCI change follow a process that is effectively the same as that process followed by both AFLC and ADCOM. For example, the change process for the E-3A AWACS, as presented in the E-3A O/S CMP, has been reviewed and found to compare quite closely with the process flow of both Figures 3-2 and 3-3. Minor differences occasionally exist but there are no really substantial differences. For example, AFLC refers to the initial change request as a Material Deficiency Report (MDR), ADCOM as either a Program Modification Request (PMR) or a Program Change Document (PCD). TAC, on the other hand, refers to the initial request as a Software Change Report (SCR). All commands treat Class I and Class II changes in a similar fashion with Class I changes (i.e., design changes) receiving more attention than Class II (discrepancy changes).

This section, in previous paragraphs, has referred to the establishment of a configuration management system to ensure the interoperability of interfaces among TAC's C^2I system. Although not stated explicitly, it is implied that the CM system ensures that CM procedures are followed when making software changes to TAC C-E systems. The roles and responsibilities of TAC CPCSB members are essentially identical to those of AFLC CPCSB members. It is this element of TAC's CM system that ensures the orderly implementation of a proposed software change.

3.2.4 SAC Support Concept

SAC has not supplemented AFR 800-14 ECS support policies and procedures as they apply to C-E systems as has AFLC with AFLCR 800-21. However, in some cases they use SACR 55-XX regulations to

manage ECS system software. Where ECS subsystems are incorporated into larger command and control systems, SAC uses the SACR 55-XX regulations to manage software changes. All ECS software changes for command and control systems must be reviewed by the SAC Automated Command and Control System (SACCS) Decision Control Board. All proposed changes must be submitted as a SACCS change request.

In addition to the 55 series regulations, SAC supports the SAC Airborne Command Post (EC-135) and the Advanced Airborne Command Post (E-4) ADP systems under 300 series regulations and AFR 800-14. Air Force management software is developed under AFR 300 series and system software under AFR 800 series. In this case, the systems software is jointly supported by WR-ALC and SAC/AD. The AABCP mission software is provided by SAC/AD and the Defense Communications Agency.

3.2.5 AFCC Support Concept

The software support policy followed by AFCC is briefly described in the penultimate paragraph of Section 3.2.

3.2.6 C-E ISF Concept

In addition to having a configuration management system that provides a means for maintaining strict configuration control of all software and software/hardware changes, each C-E system normally requires the development and acquisition of an Integration Support Facility (ISF). The major components of a generic C-E ISF are shown in Figure 3-4. No single C-E system is expected to have this exact configuration; however, the systems for which AFLC has software support responsibility are expected to have ISF's that are functionally similar. User supported systems generally include C-E systems where there is a relatively small number of sites. For these systems the ISF configuration is often unique to the system. For example, the ISF for the Joint Surveillance System (JSS) as described in Section 4.4 is composed of equipments that are identical to system equipments and its design is identical to one complete processing thread through the total system.

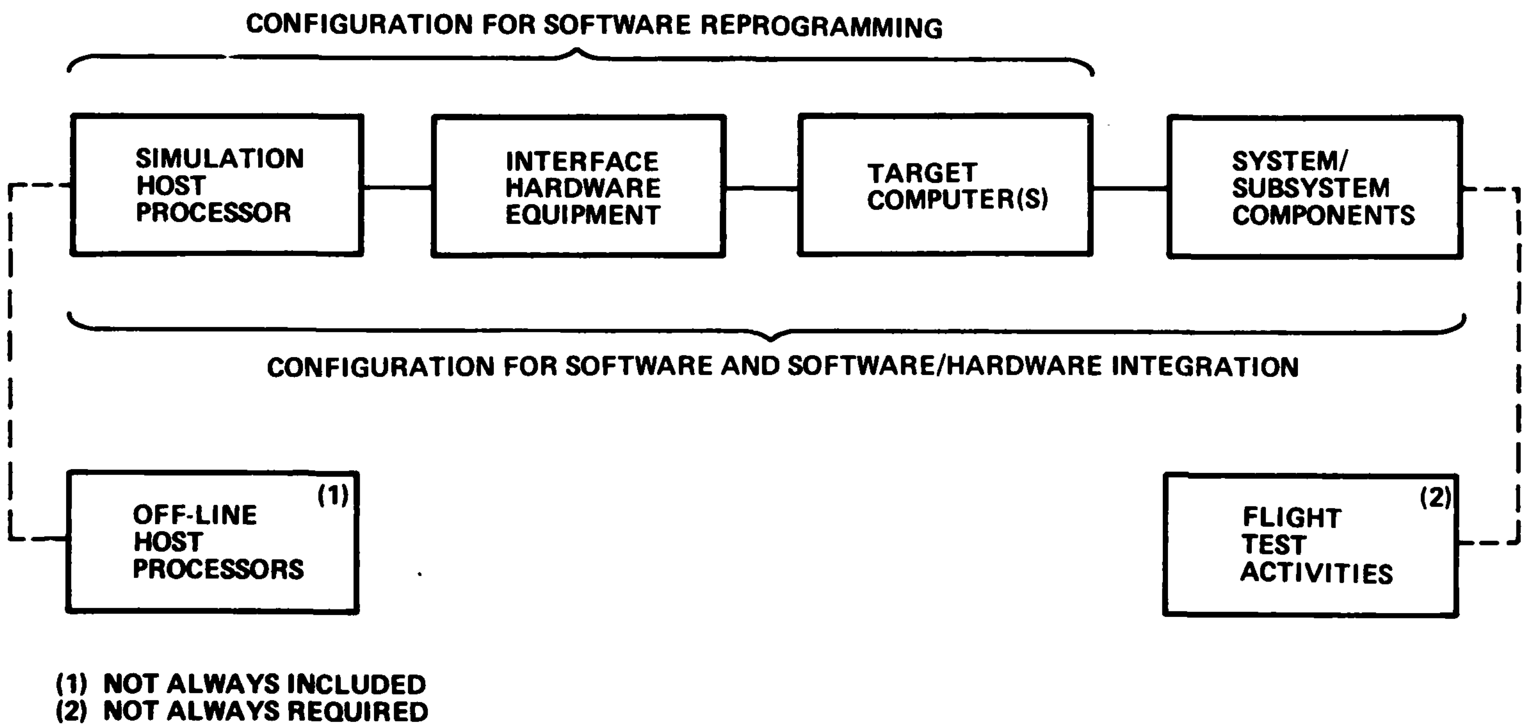


Figure 3-4. C-E ISF Components

In any case, the dynamic simulator ISF concept of Figure 3-4 which does reflect the ISF concept for many C-E systems is described more fully below.

3.2.6.1 Off-Line Host Processor

An off-line computational capability provided by a medium to large scale computer is sometimes used for engineering data management, simulation and flight test data reduction and analysis, configuration management, off-line interpretative computer simulations, various support and debugging tools, cross-assemblers and compilers, special simulation routines, and other software related tasks that can be best accomplished away from the dynamic simulation environment.

3.2.6.2 Simulation Host Processor

The simulation host processor is usually a standard, off-the-shelf, qualified minicomputer and depending upon its size and capability may also be used to accomplish many or all of the off-line host processor functions. However, this computer primarily provides the capability to drive the embedded computer in a real time, closed-loop simulation mode and to collect data from the target computer while the simulation is running. This data can then be used to analyze the performance of the operational software. The software residing in the simulation host processor would include (1) software routines to control and monitor the interface to the embedded computer; (2) software routines to process data sent to and from the system's subsystems; (3) simulations for closed-loop operation with the operational computer program; and (4) support software unique to the minicomputer-like compilers, assemblers, and operating systems.

3.2.6.3 Interface Hardware Equipment

This element between the simulation processor and the target computer will consist of an interface for loading, starting, stopping, monitoring, controlling, simulating, and displaying those functions that are inherent to a dynamic, closed-loop simulation of the system's

operation. The hardware interface would normally take the form of: (1) a computer monitor and control function which interfaces with the internal signals of the ECS for the purpose of monitoring the computer's central processing unit and controlling the operation of the computer such as changing its internal status, starting and halting program execution, and like functions; and (2) hardware interface adaptor units for switching and signal conditioning (D/A and A/D), power distribution, and control.

3.2.6.4 Target Computer(s)

Inclusion of the weapon system's target computer(s) in the ISF results in an ISF having the capability for complete software reprogramming and at least partial testing of changes to the operational software that executes in the target computer(s).

3.2.6.5 System/Subsystem Components

The inclusion, when feasible, of system components that operate under the control of the target computer (such as radars, operator displays, etc.) provides a capability to more completely test software and/or hardware changes to the system. If a full qualification test is required prior to release of the change to the operational user, these components or complete simulations of the components must be a part of the ISF. In some cases, microprocessor-based simulators may be adequate.

3.2.6.6 Flight Test Activities

In those cases where safety-of-flight considerations are of concern, it may be necessary to conduct actual flight tests to prove the changes have been made successfully. With C-E systems it is less likely that flight tests are required than with OFP systems; however, with C-E systems such as TRACALS flight test results are required for verification of changes.

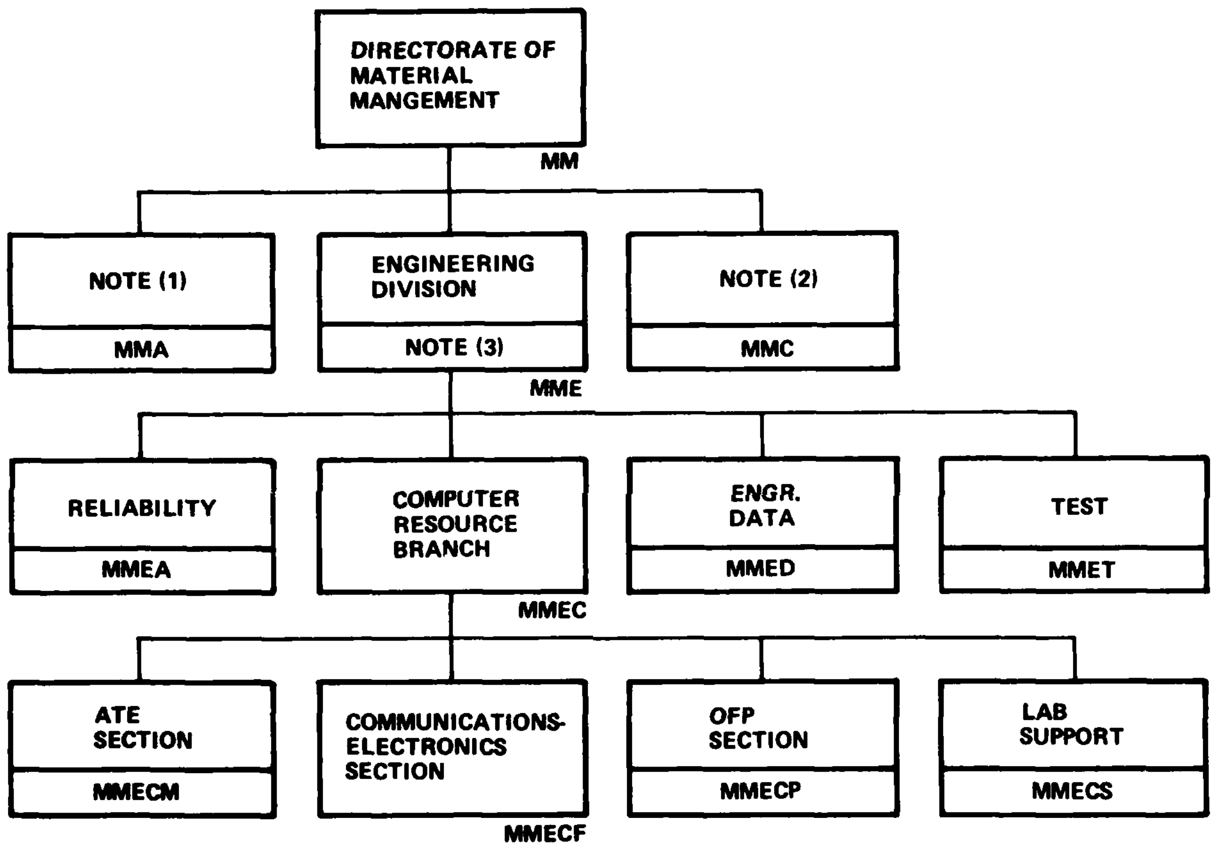
3.3 ORGANIZATIONS AND INTERFACES FOR C-E SYSTEM SUPPORT

Within AFLC there are several ALC's that are involved in providing support for the ECS computer resources of various C-E systems. SM-ALC has the support responsibility for some forty C-E systems including TRACALS, SEEK IGLOO, and JSS. OC-ALC has responsibilities for additional C-E systems. Included are the E-3A AWACS and the E-4B AABCP. WR-ALC is responsible for supporting the Joint Tactical Information Distribution System (JTIDS), among others. OO-ALC supports the Tactical Information Processing and Interpretation (TIPI) system.

Figure 3-5 illustrates the organizational structure existing at SM-ALC for supporting those C-E systems assigned to SM-ALC. Within this structure, MMEC is the branch with the responsibility for developing the necessary ECS support facilities and for implementing both software and/or hardware changes to the ECS. The figure also indicates that MMEC has been assigned responsibility for selected OFP systems and ATE systems as well as the assigned C-E systems.

One of the key C-E systems described in Section 4 that is not supported at SM-ALC is the E-3A AWACS. Responsibility for supporting this system resides at Tinker AFB, OK. For this system, the support responsibility is shared by TAC and by AFLC. At the present time TAC supports ten CPCI's while OC-ALC is developing an AISF† to support six other major E-3A CPCI's and systems integration. The TAC support facility is currently operational while the OC-ALC facility has a PMRT date of about 1982. Figure 3-6 illustrates the TAC organization at Tinker AFB that maintains the E-3A fleet and provides support for the system's complement of ECS's for which TAC is responsible. The 552nd Wing was organized and deployed to Tinker AFB during 1977.

† The facility at OC-ALC was named an AISF prior to the adaption of the term ISF.

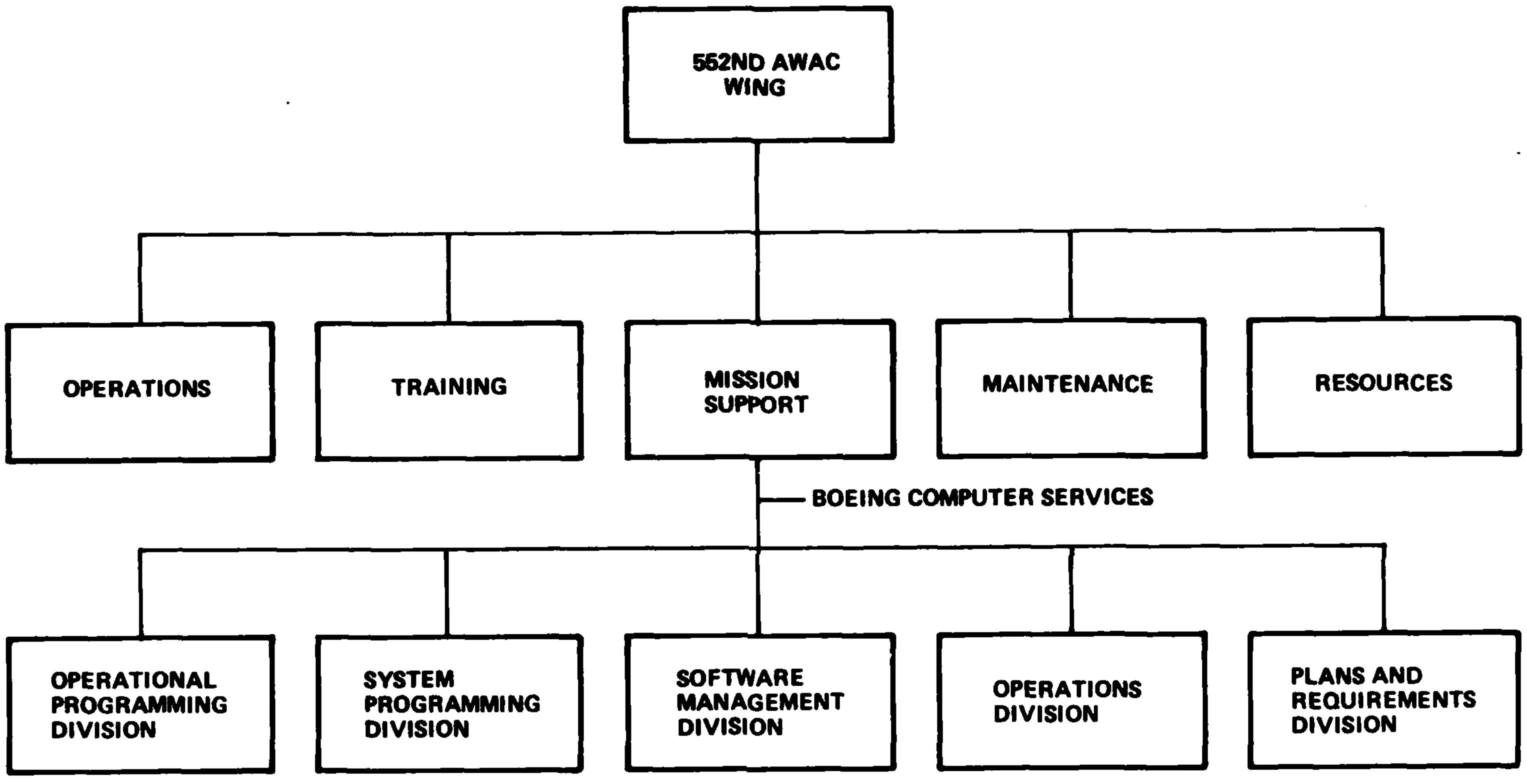


NOTE (1) - THIS DIVISION NORMALLY PROVIDES THE SM AND SE FOR SYSTEMS IN ACQUISITION.

(2) - THIS DIVISION NORMALLY PROVIDES THE SM, SE, AND HARDWARE ENGINEER FOR TRANSITIONED SYSTEMS.

(3) - THIS DIVISION NORMALLY PROVIDES THE SOFTWARE ENGINEER FOR ALL SYSTEMS.

Figure 3-5. SM/ALC Computer Resources Support Organization



NOTE (1) THIS ORGANIZATION IS RESPONSIBLE FOR SUPPORTING ONLY THOSE E-3A CPCI'S THAT ARE ASSIGNED TO TAC.

Figure 3-6. E-3A AWACS Computer Resources Support Organization

Figure 3-7 presents the structure of the AFLC units that are involved in current efforts to develop an AISF for supporting those E-3A CPCI's assigned to AFLC. When the AISF concept has been finalized this organization will become responsible for acquiring the various components and integrating them into the final product. As shown in Figure 3-7, the working interface between the OC-ALC and both TAC, as the user, and ESD, as the AWACS development SPO, is managed by the AISF Program Manager (PM). This PM is a member of the E-3A SM Branch of the Acquisition Division. When the AISF is completed (PMRT of October 1982) it will be managed and operated by those MME/MMEC personnel who are responsible for providing software support to the F-3A. The TAC side of the interface is with the Deputy for Mission Support in the 552nd AW ACS Wing. The ESD side of the interface is within the office of the Deputy for E-3A (ESD/YW).

Yet another large C-E system of primary concern to AFLC is the JTIDS. As noted above, WR-ALC is responsible for developing a JTIDS AISF and for providing support to those ECS's embedded within the JTIDS. The WR-ALC has a Material Management Directorate (MMD) that is organized in a manner similar to the MMD at SM-ALC. The Computer Resources Branch (MMEC) within the Engineering Division (MME) is the organizational component that has the primary JTIDS computer resource support responsibility. The nature of the JTIDS system is such that its support responsibility is partially shared by TAC/Langley AFB, and TAC/Tinker AFB. There is also a possibility that the WR-ALC ISF will be interfaced to the F-16 AISF at the OO-ALC. The Langley connection is via the Tactical Systems Interoperability Support Center (TSISC) in support of the TACS/TADS program. The interface management procedures/responsibilities are established in the JTIDS TAC/AFLC Memorandum of Agreement (MOA). The Tinker AFB connection is via the TAC portion of the E-3A ISF in support of E-3A mission software. This interface is between MME at WR-ALC and the Deputy for the Mission Support in the 552nd AWACS Wing at Tinker AFB.

3.4 MANAGEMENT PHILOSOPHY/CONCEPT

3.4.1 Concept of Operation

AFLCR 800-21, "Management and Support Procedures for Computer Resources Used in Defense Systems" delineates AFLC policy, a concept of operation, and agency responsibilities (both pre- and post-PMRT) for those C-E systems for which AFLC has system management responsibility.

AFLC policy prescribes, for each C-E system to be supported, that three initial primary management actions be taken. First, a Computer Resources Working Group (CRWG) is established. This group is composed of representatives from HQ AFLC, the appropriate ALC, the user, the developing command (AFSC), AFALD, and perhaps others.

Second, the CRWG prepares the Computer Resources Integration Support Plan (CRISP). This plan is an AFLC tool for identifying what AFLC needs to support the particular ECS. When completed, the CRISP contains a substantial body of information including plans/procedures to establish and operate an Integration Support Facility (ISF) for the system. Details of the ISF's equipment, software, and facility configuration will be included, insofar as they are known at the time the CRISP is prepared.

The third action involves the preparation, by the CRWG, of the Operational/Support Configuration Management Procedures (O/S CMP). This document details all configuration management procedures. It also will specify the deficiency reporting and change control procedures. The O/S CMP is the document that fleshes out the generalized management concept defined in the CRISP by specifying the specific system-related responsibilities assigned to all participating organizations.

The emphasis in the management philosophy is on using a centralized concept for both management and engineering support. A System Manager (SM) will be assigned with responsibility for program control, deficiency evaluation, system engineering, and acceptance testing. For those C-E systems wherein AFLC and the user both share management and support responsibility a joint concept will be developed by AFALD, the SM, and other relevant support agencies to delegate to each organization its role in management, engineering, maintenance, and system modifications. Since each C-E system may have unique support requirements, the joint support concept will be developed on a system-by-system basis. The nature and extent of these agreements will be documented in the system's CRISP and O/S CMP.

3.4.2 Support Management

Support Management is an activity that occurs throughout the entire life cycle of a system. It first starts at the beginning of the system's conceptual phase and ends only when the system is removed from the operational inventory at the termination of the deployment phase. Even though it is an on-going process, it is best thought of as having two distinct time periods, each with its own special features. The first period encompasses the system acquisition activities, while the second period encompasses the system support activities. The key action that defines this separation is the PMRT event. The following sections will describe some of the more important AFLC/ALC management roles and responsibilities during each of these two time periods.

3.4.2.1 Pre-PMRT Management

During the acquisition phase the development command, usually AFSC/ESD for C-E systems, will provide the overall Program Manager (PM) who is responsible for acquiring the system. The role of AFLC during this time period is to also provide a Program Manager (PM) who comes from the ALC that will support the system during its deployment phase. This PM is assigned from the Acquisition Division (MMA)

of the center's Material Management Directorate. His primary responsibility is to ensure that the developers are designing a "supportable" system. He accomplishes this with the assistance of a hardware engineer from the center's MMAR Branch and a software engineer from the MMEC Branch. The hardware engineer is sometimes also called the acquisition engineer. These ALC personnel do not participate in the actual design process, but do attend the technical review meetings (SRR, SDR, PDR, CDR, etc.) and review relevant design material to ensure the supportability of the system after it "transitions" to AFLC. For example, the software engineer is responsible for reviewing the software design and detail specifications, i.e., the B-5 and C-5 Specifications to ensure the adequacy of the software design. During this period, the hardware engineer is generally somewhat less involved with the system than is the software engineer. However, his responsibilities will include cognizance of ALC equipment and facility support requirements for the post-PMRT time period. One of his duties will be to ensure that the support requirements that are to be satisfied by the system's ISF are defined in the CRISP.

3.4.2.2 Post-PMRT Management

Subsequent to PMRT, the systems management structure undergoes a significant change. The key action is the assumption, by AFLC, of total responsibility for supporting the system. This includes the responsibility for supporting the system's computer resources (computer hardware and computer programs) as well as the basic hardware elements of the system such as radars, operator consoles, and the like.

The overall manager of the system is now called the System Manager (SM). He is a representative of the System Manager Division (MMC) of the ALC. In most cases, the division chief is named as the SM. He may, in fact, be the designated SM for several systems.

At this point in time, i.e., PMRT, several key personnel are relieved of any further contact with the system. The AFSC/ESD PM no longer has any management responsibility since the system is now out of acquisition and has become operational. The ALC/MMA PM and the MMAR hardware/acquisition engineer are also relieved of any further responsibility since the new SM from MMC has the overall system management role. The software engineer continues to hold his former responsibility. However, he now performs his role in support of the SM rather than the ALC PM. If the ALC has an ISF for use in supporting the system, the software engineer will play an active role in its use in the software change process. If the using command is to support all or most of the software, the software engineer's primary role is to review/assess any contemplated software changes to be implemented by the user. Although the user is to implement the software change, the SM at the ALC continues to have total support responsibility and must approve all software changes. He uses the expertise of the MMEC software engineer to guide his decision.

With respect to hardware engineering support, the SM draws on the personnel within MMC's Engineering and Reliability Branch (MMCR). Thus, the role that was previously played by the MMAR hardware engineer is now filled by MMCR engineers. Within this branch are both system engineers and selected hardware engineers. Specific hardware engineers are assigned program responsibilities as their respective skills are required. In addition to their roles in support of strictly hardware changes to the system, these engineers will also be involved in evaluating the affects of any software changes that have a hardware impact.

3.5 HARDWARE MAINTENANCE PHILOSOPHY/CONCEPT

For the past several years the Air Force and AFLC have used a tri-level concept for maintenance. The levels of maintenance within this concept are identified as organization, intermediate, and depot. The basic tenet of this approach is that certain repair is most cost effective if completed at an individual organizational level, while other repairs indicate a composite or pooling of equipment and personnel

is most efficient. This latter case represents the intermediate level between organizational and depot levels. Certain other repair activities necessitate extensive equipment and expertise such that the additional equipment and qualified personnel consolidated at the depot level is necessary for efficient repair completions.

Using the described concept, item maintenance of ECS C-E systems is essentially the same as for non-ECS systems, that is, when depot level maintenance is required, a Technical Repair Center (TRC) is responsible for providing automatic testing where applicable and repairing black boxes as their deficiencies are discovered. One deviation from normal is begun when support is required for a C-E support system, such as an IBM 370 computer. The support system may be commercial equipment or "one of a kind" for which no repair capability may exist at any TRC. This means that subscription service, if available, must be bought from the equipment manufacturer and the responsibility for black box maintenance contracted.

The overriding AFLC philosophy is to use current AFLC management and repair policies where possible, and to use individualized system maintenance as a last report alternative.

4. REPRESENTATIVE SYSTEMS AND SUPPORT SYSTEMS

This section describes five representative C-E systems selected for an in-depth analysis as to the adequacy of their existing/planned post-PMRT software support posture. The five systems have been chosen from a total set of some fifty C-E systems (see Table 1-1 of Section 1). The specific systems have been selected to represent a variety of PMRT dates and a variety of command and/or installations having software support responsibility. The specific systems, their PMRT date, and the software support organization are presented in Table 4-1.

As can be seen in the table, both the TRACALS and SEEK IGLOO systems are completely supported by SM-ALC. That is, SM-ALC will have an ISF for each system and will be responsible for supporting all system CPCI's, be they operational CPCI's or test and diagnostic (support) CPCI's. E-3A AWACS support responsibility will be shared by TAC and OC-ALC. TAC (552nd AWACS Wing) is primarily responsible for the Airborne Operational Computer Program (AOCP) that resides in the E-3A's central computer, while OC-ALC is responsible for the airborne surveillance radar program that resides in the radar computer. Each is also responsible for portions of the various support and test software packages. As shown, ADTAC (formerly ADCOM) is completely responsible for maintaining the JSS CPCI's. ADTAC and SM-ALC are currently discussing whether SM-ALC or ADTAC will support the Diagnostic Set (DIS) CPCI. The final decision has not yet been made, however, this report assumes ADTAC will support the total JSS software complement. Finally, JTIDS CPCI's are shown to be shared between WR-ALC and TAC HQ (Langley AFB). TAC is responsible for the operational computer programs in one of the ASIT's two computers (IBM ML-1).

Table 4-1. Representative C-E Systems

System Name	Support Organization	PMRT Date	CRISP	O/S CMP
TRACALS				
TPN/19	SM-ALC	10/1976	Signed	Signed
GPN/24	SM-ALC	1985	Draft	Draft
SEEK IGLOO				
MARS	SM-ALC	6/1984	Signed	None
E-3A AWACS	TAC	10/1977	Signed	Signed
	OC-ALC, Phase I	3/1983	Signed	Signed
	OC-ALC, Phase II	3/1984		
JSS	ADTAC	12/1982	Draft	None
JTIDS				
HIT	WR-ALC	7/1983	Draft	None
ASIT	WR-ALC	2/1984	Draft	None
ASIT	TAC	2/1984	Draft	None

Each of the following subsections will present (1) a general description of the selected system with emphasis on the ECS and associated CPCI's (2) a description of the existing/planned support system including a functional schematic of the ISF, and (3) an assessment of the adequacy of the current/planned support posture, i.e., does it or will it meet the inherent requirements, and is it in accordance with the general concept for supporting ECS software.

The Support Posture Evaluation subsections in each of the following Sections (4.1 through 4.5) contain qualified judgements about the system's support posture that should prove correct if the ISF's are completed as presently planned.

4.1 TRACALS - 404L

4.1.1 System Description

Traffic Control and Landing System (TRACALS) is included as part of project 404L. The overall objective of this project is to provide fixed and mobile ground facilities and equipments and associated electronics for safe and expeditious aircraft movements on a worldwide basis. Included in this on-going program are two systems that are of interest to this study. These two systems are the AN/TPN-19 and the AN/GPN-24(V) Landing Control Centrals (LCC's).

The AN/TPN-19 LCC is a highly mobile, self-contained, terminal area ATC system used to support both tactical air base and emergency mission support requirements. The system is composed of the AN/TPN-24 ASR, the AN/TPN-25 PAR, and an operations center (OPS). Current plans call for 11 systems to be procured.

The AN/GPN-24(V) LCC was developed to satisfy the fixed based portion of the USAF air traffic control requirements. The system was designed to provide modern reliable, air transportable terminal radar system support of worldwide operations, and is composed of

four segments: (a) AN/GPN-20 Airport Surveillance Radar (ASR), (b) AN/GSN-12 Operations Center (OPS), (c) AN/GPN-22 High Performance Precision Approach Radar (HI-PAR), and (b) AN/FPN-62 Normal Performance Precision Approach Radar (N-PAR). Current plans call for 39 systems to be procured.

The AN/TPN-19 system has been an operational system since about 1976. However, the TPN-19 SPO (ESD/OCN) and prime contractor (Raytheon) are still providing software support to the system. SPO/contractor support has continued past the system's IOC primarily to finish correcting deficiencies that were discovered prior to IOC. Also the ISF at SM-ALC was not operational, however, present schedules call for this situation to change by late 1980 as the SM-ALC develops the TRACALS ISF and thus a capability to provide software support to the system.

The GPN-24 system is presently in the final stages of its test program and has a scheduled PMRTD of September 1980. Due to the similarity of these two systems, current plans at SM-ALC indicate that they will both be supported using the same ISF.

The computer resources of the LCC system include two separate ECS's. The primary ECS is a specially designed Target Data Computer (TDC) which stores and executes the radar operational program. The TDC program accepts operator target designations in order to acquire and track up to six targets simultaneously. The TDC provides the final approach controllers with filtered estimates of the range, azimuth, and elevation of tracked targets. The TDC scans a volume $\pm 10^{\circ}$ in azimuth and from -1° to 7° or 14° in elevation. The radar beam swell for target tracking is time-shared between scan beam dwell time.

The second computer is a TI 980B hard-wired, non-programmable processor. It is part of the AN/GSN-12 Operations Center and provides display information to the operator display consoles.

The TDC software package includes both functional and diagnostic software programs. The functional software is included in one CPCI while the diagnostic software consists of two CPCI's.

As shown in Figure 4-1, the TDC operational program is the center of the PAR control system. The TDC sends radar beam angle commands to the Antenna Beam Position Control (ABPC), which controls the phase of the elements of the array antenna. Target range data is transmitted to the Video Processor (VP) which gates radar signal returns and sends the TDC both range and beam pointing errors. Operator target designations and PAR mode commands are processed by the TDC, while target and scan data are displayed graphically on the CRT's of the display consoles. In addition, the TDC program accepts and processes runway site parameters as indicated on the Site Parameter Panel (SPP).

This program includes the following functions:

- An overall executive control of all program components.
- Initialization of the program components.
- The data processing required to enable the acquisition of targets selected by Ground Control Approach (GCA) radar operators.
- The presentation of tracked target data and glide path data to GCA operators.
- Automatic recovery from computer faults due to transient power failure, illegal computer instruction, and computer program overtime run.
- Detection of computer program faults and peripheral interface faults.

The diagnostic CPCI's include a System Performance Assessment (SPA) program and a computer diagnostic program for automatic checkout of the TDC computer hardware.

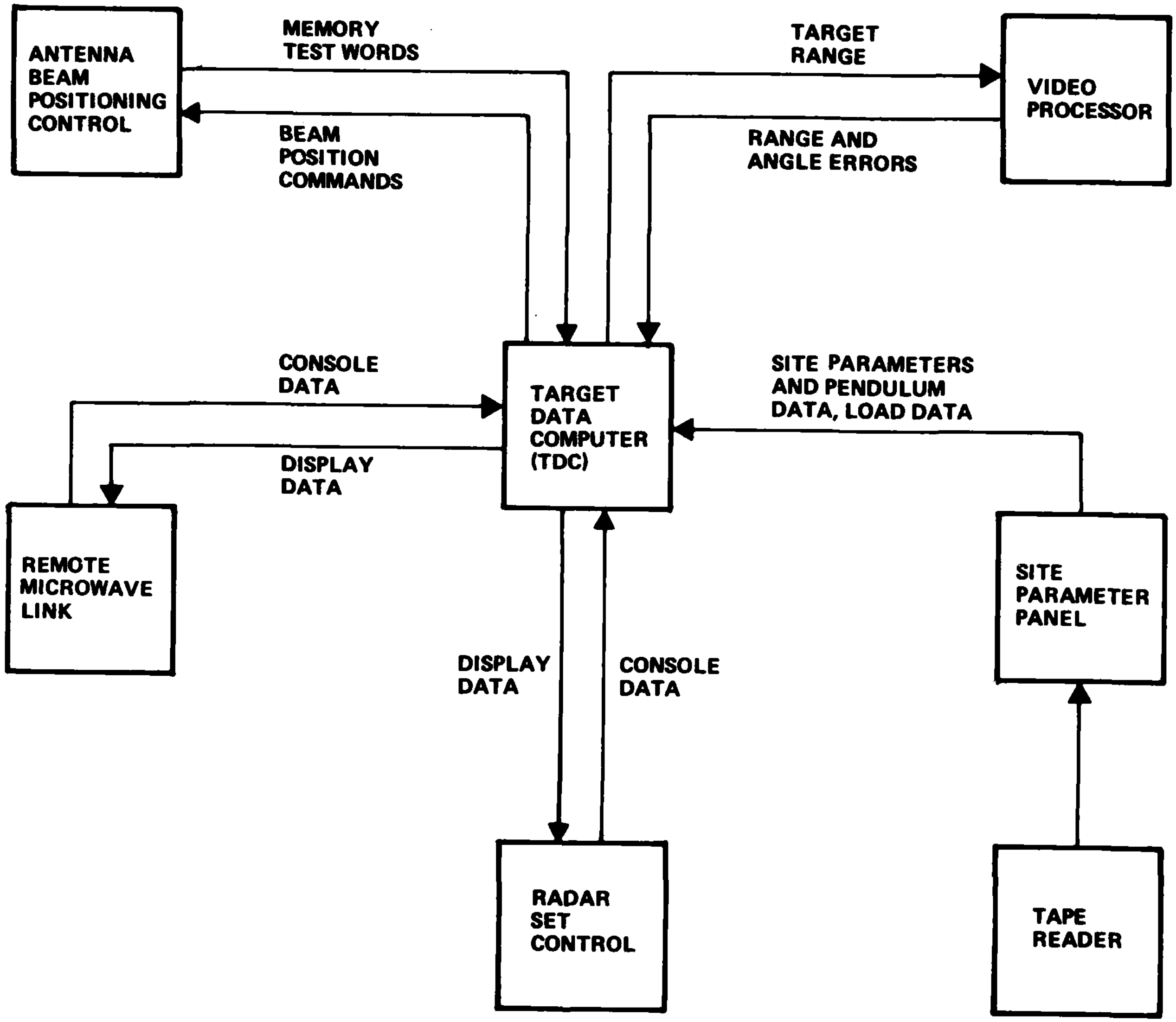


Figure 4-1. Target Data Computer Interfaces

The TDC in both the TPN-19 and the GPN-24 is a militarized, general purpose, minicomputer (RAC 251) with a 32-bit word length and 4K resident core memory. The program size for the three CPCI's in terms of the number of instructions is as follows: Operational, 3.8K; SPA, 3.4K; and computer diagnostic, 4.0K.

The TI 980B does not use software as such. Production drawings for Integrated Circuits (IC's) will identify ROM pattern requirements.

4.1.2 Support System

4.1.2.1 Software Support

The SM-ALC (MMEC) is assigned the responsibility of providing software support to both Test and Diagnostic (T&D) and operational computer programs for the AN/TPN-19 and the AN/GPN-24(V) Landing Control Centrals. That is, SM-ALC will support the reprogramming of all software that executes in the TDC computer of each system. Any reprogramming of the firmware in the TI 980B processors will be the responsibility of the WR-ALC.

SM-ALC has prepared a 3-phase plan that, when implemented, will provide an ISF to support both the TPN-19 and GPN-24.

The Phase I configuration of the ISF will incorporate an HP-1000 minicomputer as the host processor (complete with associated peripherals), a target data computer (RAC 251), and the necessary interface equipment. A software-based simulator will be developed and integrated to provide a means for modelling the TPN-19/GPN-24 peripheral hardware. This configuration will be somewhat limited in capability in that it will be able only to resolve pure software problems. Phase I is scheduled for operation by December 1980.

The Phase II configuration will incorporate up to four Motorola 68000 16-bit microprocessors to model the TPN-19/GPN-24 peripheral hardware. The configuration will enhance the Phase I capabilities by aiding the capability to resolve software/hardware integration problems and to develop enhancements. Phase II is scheduled for operation by November 1981.

The Phase III configuration will allow the replacement of the microprocessors that are simulating the peripheral hardware with actual peripheral hardware. This change will provide several enhancements: troubleshooting of system hardware will be possible, software development and evaluation will be more readily accomplished, the capability will exist to perform independent verification and validation of system modifications, and the facility will be able to support the technical repair center [SM-ALC (MAI)] responsible for depot repair of the TDC. The operational date of this configuration has not yet been determined.

Figure 4-2 illustrates the specific components of the TRACALS ISF.

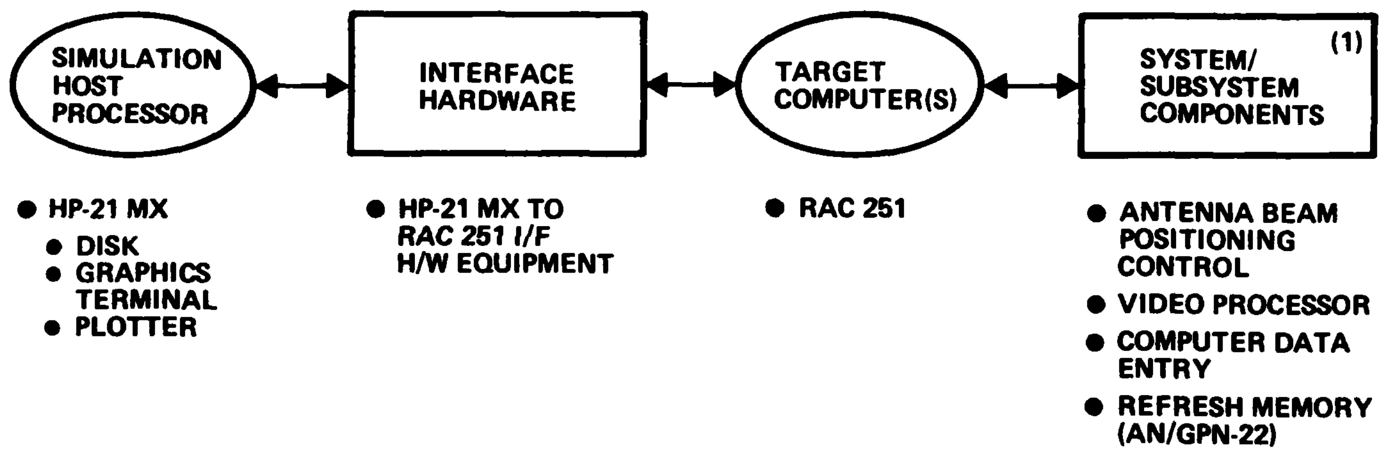
4.1.2.2 Hardware Support

The maintenance concept for the TPN-19/GPN-24 computer hardware is essentially a 2-level concept instead of the standard 3-level concept. The organizational level and the intermediate level are basically combined into a single Org/Int level. At this level the site personnel will use the diagnostic software to isolate faults to the failed boards within the TDC. The failed boards will be replaced by operable boards with the failed boards returned to the depot for repair. SM-ALC (MAI) is the designated Technical Repair Center (TRC) for performing depot maintenance on the TPN-19/GPN-24 TDC.

WR-ALC is responsible for both computer hardware and firmware maintenance on the TI 980B computer.

4.1.3 Support Posture Evaluation

The TRACAL ISF is currently in the early stages of implementation at SM-ALC and is not yet operational. This facility was designed to support both the AN/TPN-19 and the AN/GPN-24. The TPN-19 CRISP and O/S CMP have been signed and are available to guide the management of ECS support. On the other hand the CRISP and O/S CMP for the GPN-24 have not been signed. Both of these documents are in draft awaiting further review and coordination. These documents should be completed prior to PMRT. The GPN-19 PMRT took place in 1979.



(1) PHASE I: THESE SUBSYSTEMS WILL BE SIMULATED IN THE HP-21 MX.
PHASE II: THESE SUBSYSTEMS WILL BE SIMULATED WITH μ PROCESSORS.
PHASE III: THESE SUBSYSTEMS WILL BE ACTUAL SYSTEM COMPONENTS.

Figure 4-2. TRACALS - 404L ISF Components

Table 4-2 presents an assessment of the planned TRACALS support posture when compared to the ECS support requirements presented in Section 2. The comments are grouped by the six functional categories listed in Section 2.

4.2 SEEK IGLOO - AN/FPS-117

4.2.1 System Description

The SEEK IGLOO program will provide improved operational capability for the Alaskan Air Command's (AAC) thirteen radar sensor sites (plus a system training facility) and will significantly reduce life cycle costs through implementation of a Minimally Attended Radar (MAR) concept. This concept requires existing equipment (the AN/FPS-93A surveillance radar, supplemented by the AN/FPS-6/90 height finder at nine of the thirteen locations) to be replaced with a single current generation 3D radar system having integral height finding capability, improved beacon equipment, and greater reliability/maintainability. The current generation radar equipment will also have built-in fault detection and isolation functions which enable on-site personnel to isolate and replace failed components. Other automatic features include jamming strobe reporting as well as digital extraction and narrow-band remoting of target information. Implementation of the MAR system with the JSS ROCC will eliminate the need for radar operations personnel at the radar sites and will result in substantial reductions in remote radar sites maintenance manning to a maximum of three personnel per site.

The MAR system will provide surveillance and ground control intercept at distances up to 200 nautical miles and improved detection in heavy ground, sea, and weather clutter. Each radar will provide search, height, beacon identification, strobe, and other data for transmission to the Region Operations Control Center (ROCC) at

Table 4-2. TRACALS Support Posture Status

Support Requirements	Findings/Remarks
ECS Change	ISF is not operational and the contractor continues to support the software. The ISF description in the GPN-24 CRISP does not fully identify all required resources to support the reprogramming facility (manpower, space, specific support software, etc.)
Change Analysis and Specification	A support team has been assigned to the ISF, but CPCI's are currently maintained by the contractor.
Engineering Development and Unit Test	Requirements are adequately covered in the draft O/S CMP; however, specialized engineering development and test software is not described in the CRISP.
System Integration and Test	Requirements are adequately covered in the draft O/S CMP. The requirements for system test and evaluation software are not called out in the CRISP.
Change Documentation	Normal CPIN reporting will be used. Rapid changes to the CPCI are not anticipated and this method of reporting is assessed to be adequate.
Certification and Distribution	A TCTO will be used to distribute changed CPCI's and related change documents.

Elmendorf AFB, thus supporting implementation of the Joint Surveillance System (JSS) program in Alaska. The capability will also exist for limited autonomous operation in the event of failure of either the communication path to the ROCC or the ROCC itself.

The SEEK IGLOO MAR's will be developed in three phases. Phase I was a six month design validation phase involving three contractors. The participating contractors completed by submitting Type B Specifications and conducting a Preliminary Design Review (PDR) for evaluation. A second selection process was conducted at the end of Phase I. One contractor was selected and entered Phase II (full scale development). Phase II consists of fabrication and developmental testing of two pre-production radars to include IOT&E of one MAR at King Salmon APRT, Alaska. Following Phase II, a production contract will be awarded commencing the third and final phase. Phase III includes the refurbishment of the two preproduction MAR's, production, delivery, and installation of 12 SEEK IGLOO MAR's, delivery of a training system, and delivery of depot support equipment. The General Electric Company is currently performing on Phase II of the program.

The computer resources of a SEEK IGLOO MAR site include four different kinds of ECS's. They are as follows:

1. General Electric - Federation of Functional Processor/ Digital Data Processor (FFP/DDP). This is a mini-computer with a 16-bit word length and 2 Mbytes of memory.

2. Texas Instruments - TI 9900 Microprocessor.

3. Advanced Micro Devices - AMD 2900 Microprocessor.

4. Intel 8086 Microprocessor.

There are six separate Functional Application Software (FASW) CPCI's that are being developed for execution in these computers.

The following paragraphs briefly describe each of these CPCI's.

- Data Processor Mission Software (DPMS). The DPMS CPCI is resident in the Digital Data Processor (DDP) and performs routine radar control functions associated with the maintenance of surveillance beams and Monitoring/Fault Isolation (M/FI). Target and strobe detections from the radar and target identification from the Beacon Interrogator are processed and reported to the ROCC. The DPMS CPCI provides for the generation of radar system test commands, the collection of test data, and the reporting of test conclusions. DPMS also provides automatic reconfiguration around failed redundant elements.

- Display Mission Software (DMS). The DMS CPCI is resident in the TI/SPB 9900 Microprocessor, an element of the display data processor in the Operations Control Group. The DMS CPCI supports operator-entered initialization commands, manual initiation of targets, allows the entering of console control messages, and supports other operator-entered commands.

- Beacon Mission Software (BMS). The BMS CPCI is resident in the Intel 8086 microprocessors, an element of the beacon interrogation and processing equipment in the Process and Control Group. The BMS CPCI designates SIF mode interrogation codes according to predetermined interface patterns, performs fault monitoring and isolation tests, accepts decoded IFF video for target identification, and reports reply code and azimuth information to the DDP.

- Radar Support Software (RSS). The RSS CPCI is resident in the DDP in the off-line mode. The RSS CPCI provides M/FI capability for all elements of the MAR system except the DDP (which is performed by the existing DP off-line diagnostics). RSS initializes off-line M/FI programs for the radar system, controls the execution of test sequences, analyzes test data, and reports M/FI test results.

- Data Processor Support Software (DPSS). The DPSS CPCI is an existing program for DP off-line diagnostics.

- Data Processor Operating System (DPOS). The DPOS CPCI is an existing program to permit operation of the GE FFP/DDP computer.

4.2.2 Support System

4.2.2.1 Software Support

The SM-ALC (MMEC) is assigned the responsibility of providing software support to both Test and Diagnostic (T&D) and operational computer programs for the SEEK IGLOO MAR systems. That is, SM-ALC will support the reprogramming of all software that executes in the GE FFP/DDP computer. SM-ALC will also support the reprogramming of all firmware in the TI 9900, AMD 2900, and Intel 8086 microprocessors.

SM-ALC is monitoring the contractor's development of a software development facility (i.e., an ISF) that SM-ALC will use to meet its software support responsibilities. This facility is scheduled for delivery in January 1984. When operational at SM-ALC the facility will have the capability to reprogram both MAR software and firmware. Since the facility is not scheduled to have a hot mockup MAR, integration testing will have to be conducted at an operational site.

In addition, the facility will not be able to simulate the Beacon Mission Software. Thus, BMSW changes cannot be tested in-house and will require field testing.

When operational, the support facility at SM-ALC will incorporate the following computer components as well as necessary interface equipment.

- GE FFP/DDP target computer
- DEC PDP 11/70 host processor
- Tektronix 8002 microprocessor tab with TI 9900 (option)
- AMD 2900 microprocessor

The necessary support facility software will include two basic software packages and seven Non-Functional Software (NFSW) CPCI's. They are as follows:

- GE FFP/DDP Computer FORTRAN Compiler
- Copies of the six FASW CPCI Programs

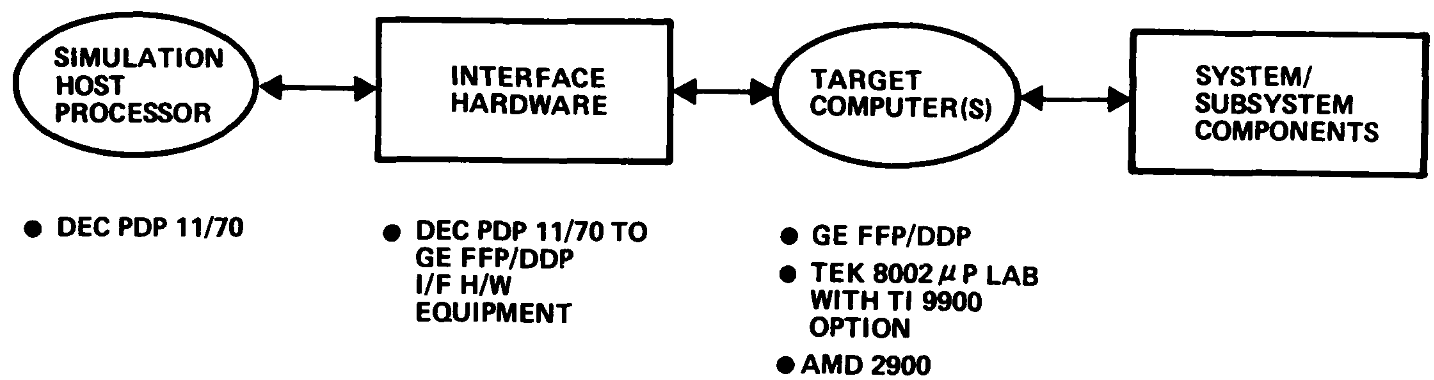
- Data Processor FORTRAN Compiler NFSW
- DEC PDP 11/70 NFSW
- Data Processor NFSW
- Digital Board Tester NFSW
- TI 9900 NFSW
- AMD 2900 NFSW
- Intel 8086 NFSW

Figure 4-3 has been prepared to illustrate the specific components of the SEEK IGLOO ISF.

4.2.2.2 Hardware Support

The Alaskan Air Command (AAC) will be responsible for organizational and intermediate level maintenance. AFLC will be responsible for depot level maintenance of computer resources. All software changes will be accomplished at the depot level at SM-ALC. However, the final stages of integration testing will be accomplished at a field location as the ISF will not have a hot mockup.

Organizational maintenance shall be based upon remove and replace "on equipment" actions at the Line Replaceable Unit (LRU) level. An LRU is constructed to be that unit/module/subassembly which is a self-contained plug-in unit to which a fault can be isolated. All LRU's shall be readily removable without disassembly of the next higher assembly; i.e., unbolting, unsoldering, etc., other than disconnecting of cables (coaxial, cannon plug, or strip line connectors). Organizational maintenance shall be within the capability of one on-site crew of no more than three maintenance personnel trained on the equipment. Organizational maintenance shall be assisted by an automated monitoring and fault isolation system.



(1): AT PRESENT THERE ARE NO PLANS TO INCORPORATE A MAR IN THE ISF. THUS, ALL SYSTEM COMPONENTS WILL BE SIMULATED.

Figure 4-3. SEEK IGLOO ISF Components

Intermediate level maintenance shall be performed either on-station by specialists dispatched from Elmendorf AFB or at the Centralized Maintenance Facility (CMF) at Elmendorf AFB. At the CMF, LRU's will be repaired using appropriate support equipment.

Depot level maintenance shall be accomplished either on-station or at the CMF at Elmendorf AFB, or at SM-ALC. Depot level maintenance shall include those tasks beyond the capability of the organizational and intermediate level maintenance facilities.

4.2.3 Support Posture Evaluation

The SEEK IGLOO ISF is to be developed by the contractor and delivered to SM-ALC. The current schedule calls for its delivery in January 1984. If the SEEK IGLOO ISF is completed according to current specifications it will provide a capability that is sufficient to support all of the SEEK IGLOO CPCI's. However, since the ISF is not scheduled to have a hot mockup radar it will be necessary to conduct final verification and validation of software changes at an operational site. The procedures for changing SEEK IGLOO computer programs, screening and reviewing these change requests and recommended fixes, conducting development and operational tests, and distributing CPCI changes have not been finalized.

Table 4-3 presents an assessment of the adequacy of the planned SEEK IGLOO support posture when compared to the ECS support requirements presented in Section 2. The comments are grouped into the same six functional areas in which Section 2 has grouped the support requirements.

4.3 E-3A AWACS

4.3.1 System Description

The Airborne Warning and Control System (AWACS) designated as the E-3A aircraft is a converted Boeing 707-320. It is configured with the latest communications, radar, and computer equipment and

Table 4-3. SEEK IGLOO Support Posture Status

Support Requirements	Findings/Remarks
ECS Change	The CRISP adequately describes an ISF capable of supporting the development of ECS changes. This facility is being developed by the contractor for delivery in 1984. Pending delivery and installation of the ISF and completion of operator training, CPCI changes will be made by the contractor.
Change Analysis and Specification	An ISF support team has not yet been identified nor trained to support the system. The required training is described in the CRISP.
Engineering Development and Unit Test	When operational, the ISF will provide a means for integrating software changes into the overall system. All modules can be tested except the Beacon software. CPCI change V&V requirements should be strengthened in the CRISP.
Systems Integration and Test	The planned configuration of the ISF will allow testing of both MAR software and firmware. However, the ISF will not have a hot mockup, therefore final software integration must be accomplished at a field site. Beacon mission software changes will also require field integration testing. CPCI change V&V requirements should be reviewed and strengthened.
Change Documentation	The O/S CMP has not been published.
Certification and Distribution	See above.

provides a surveillance and command and control capability for tactical air units. Its most conspicuous feature is a 30-foot diameter black and white radar rotodome sitting atop two pylons jutting up from the rear of the fuselage. The elliptical dome houses a specially developed radar capable of detecting and tracking aircraft more than 250 miles away at all altitudes over land and water in any direction. Its avionics suite enables the E-3A to perform command and control for a wide range of air missions including air superiority, airlift, reconnaissance, interdiction, and close air support.

The highly complex avionics suite incorporates a sophisticated computer system including both airborne and ground-based elements. The airborne element contains four computers: an IBM 4 π CC-1 which serves as the central data processor, a Westinghouse AN/AYK-8 which serves as a radar data correlator, a Delco Carousel IV, and a Northrop NDC 1070. The Delco computer is part of the inertial navigation system while the Northrop computer is part of the Omega navigation system. The ground support element is currently composed of four existing hardware/software systems with one more system to be added that is presently in the planning stage. The four systems are the IBM 370/155 large-scale data processor, a mission simulator incorporating a modified IBM 4 π CC-1, an individual positional trainer system also incorporating a modified IBM 4 π CC-1, and a flight simulator built around a Redifon 2000A computer. The fifth ground-based support system is to be the Avionics Integration Support Facility (AISF).

The AWACS system is one of several C-E systems in the inventory that will be supported in part by the user (in this case, TAC) and in part by AFLC. The TAC support is provided by the 552nd AWACS Wing while the AFLC support is provided by the acquisition (MMA) and engineering (MME) divisions of OC-ALC.

Table 4-4 presents a list of the primary AWACS CPCI's that require software support. As noted, TAC is responsible for ten of the system's major CPCI's while AFLC is responsible for seven CPCI's. Two of the seven CPCI's are in the OFP category. The table also indicates the operational computer in which each CPCI executes and whether the program is airborne or ground-based.

Among the airborne computers the IBM 4 π CC-1 is the central on-board computer, and uses the Airborne Operational Computer Program (AOCP). This program accepts radar and navigation data input from the radar and navigation computers to help the mission crew detect, track, and identify targets, commit and control weapons resources, and display and record data. In addition, system maintenance and in-flight performance programs function under the control of the AOCP, monitoring computer hardware operation and providing maintenance information to the on-board computer operator. With the ability to analyze failures, the programs automatically switch in redundant equipment or alert the computer operator to replace components.

An airborne utility program provides printouts of operational and maintenance information. A preflight GO/NO-GO hardware check of the computer system is performed by a pre-mission readiness program. More comprehensive fault isolation of on-board equipment is provided by the aircraft's diagnostic maintenance program.

The second airborne computer system, the Westinghouse Radar Data Correlator (RDC) responds to command signals received from the airborne operational computer program. It processes radar target data for use by the operators. A built-in fault isolation capability monitors the radar hardware's status.

Rounding out the airborne element are the Delco Inertial and the Northrop Omega navigational computers. They provide the E-3A's position and attitude to the flight crew, radar, and airborne operational computer program.

Table 4-4. E-3A AWACS Primary CPCI's

CPCI Name	Responsible Command	Operational Computer	Category
Airborne Operational CP	TAC	IBM 4 π CC-1	Airborne
Systems Maintenance CP	TAC	IBM 4 π CC-1	Airborne
In-Flight Performance CP	TAC	IBM 4 π CC-1	Airborne
Utility CP	TAC	IBM 4 π CC-1	Airborne
Ground Support CP	TAC	IBM 4 π CC-1	Airborne
Pre-Mission Readiness CP	AFLC	IBM 4 π CC-1	Airbone
Diagnostic Maintenance CP	AFLC	IBM 4 π CC-1	Airborne
System Maintenance CP Fault Trees	AFLC	IBM 4 π CC-1	Airborne
Surveillance Radar CP	AFLC	Westinghouse RDC	Airborne
Surveillance Radar Ground Support CP	AFLC	Note (1)	Ground-Based
Navigation CP (Omega Nav)	AFLC	Northrop NDC 1070	Airborne (OFP)
Navigation CP (Inertial Nav)	AFLC	Delco Carousel IV	Airborne (OFP)
IBM 370/155 OS and Utilities	TAC	IBM 370/155	Ground-Based
Utility CP	TAC	IBM 370/155	Ground-Based
System Exercise and Analysis CP	TAC	IBM 370/155	Ground-Based
Mission Simulator CP	TAC	Note (2)	Ground-Based
Individual Positional Trainer CP	TAC	Note (2)	Ground-Based
Flight Simulator CP	AFLC	Redifon 2000A	Ground-Based

Note (1) **This program operates in the IBM 370/155. One subprogram operates in the RDC.**

(2) **These two ground-based programs operate in a modified IBM 4 π CC-1 computer supported by the IBM 370/155.**

Among the ground-based support elements of the system the IBM 370/155 is the primary support computer. A 370/155 resident ground utility program supports maintenance of the operational software by generating master tapes for the 4 π computer and preparing simulation data for program testing. It also provides display background geography and generates theater unique operational information. A systems exercise and analysis computer program generates exercise tapes for testing the operational program and for training personnel on-board the E-3A or in the mission simulator. The program also reduces the recorded data to summarize command and control activities, give exercise results, and provide a weapons utilization summary and other operational information.

The mission simulator computer program operates in a modified IBM 4 π and provides training for E-3A mission crews. Essentially, it is a modified version of the Airborne Operational Computer Program (AOCP), but in addition includes instructor provisions and total simulation of IFF and navigation, and has replay capabilities. The simulator also provides a means for limited checkout and testing of the AOCP.

The individual positional trainer program operates in another modified IBM 4 π and provides realistic training for individual crew members by using a modified version of the AOCP for independent instruction. This trainer is operated by TAC for the purpose of qualifying individual mission crew members in the performance of duties associated with data display and control.

The flight simulator computer program which executes in a Redifon 2000A computer is an advanced version of other Air Force flight crew simulators. Its support program provides real time computation and inputs to implement major aircraft systems in a simulation mode.

The E-3A AWACS AISF is currently still in the planning and development phase. It will provide the necessary mission avionics,

computers, and software tools to allow OC-ALC to organically maintain their assigned E-3A CPCI's. Of the seven CPCI's that Table 4-4 indicates AFLC is to support, six are to be supported by the AISF. They are as follows:

- Surveillance Radar CP
- Surveillance Radar Ground Support CP
- Navigation CP
- Pre-Mission Readiness CP
- Diagnostic Maintenance CP
- System Maintenance CP Fault Trees
- The Flight Simulator CP is a self-supporting stand-alone program not supported in the AISF

The AISF-supported computer programs are briefly described in the following paragraphs.

4.3.1.1 Surveillance Radar Computer Program

The Surveillance Radar Computer Program (SRCP) executes in the E-3A Westinghouse Radar Data Correlator (RDC). The RDC consists of a dual processor with separate core program memory and MOS data memory, a special handwired processor for pulse doppler range resolution, and an I/O unit for communicating with the radar subsystems and the Interface Adapter Unit (IAU). The SRCP is organized into a program which is normally resident in the RDC and a fault isolation test library which resides off-line on magnetic tape. The SRCP is divided into three major functional areas: Data Processing and Control (DPAC), Fault Detection (FD), and Fault Isolation Test (FIT).

- Data processing and control - DPAC software provides the specific radar functions of I/O control and data sequencing, data memory allocation management, mode control, beam stabilization, main beam clutter tracking, range resolution, correlation of radar returns over multiple modulation periods, data processing for pulse doppler and ECCM, and target formatting.

- Fault detection - FD software provides continuous monitoring of various GO/NO-GO fault indications of the radar. Interleaved tests are performed to diagnose faults in the RDC or in the communications links with other radar subsystems. Dedicated time tests and manually selectable tests provide detailed diagnosis of radar units. The FD software controls execution of all tests during turn-on and normal operation If parameters or test results require it, the FD software controls reconfiguration of the radar by switching in redundant units.

- Fault isolation test - FIT software consists of detailed tests to isolate radar faults to replaceable units in major radar subsystem elements. These tests normally reside off-line, and when requested (manually or automatically) they are loaded into the RDC. In general, DPAC routines are over-written and reloading of the resident operational program occurs automatically at the completion of FIT execution.

The SRCP is written in RDC assembly language and is maintained by use of the Surveillance Radar Ground Support Computer Program (SRGSCP).

4.3.1.2 Surveillance Radar Ground Support Computer Program

The Surveillance Radar Ground Support Computer Program (SRGSCP) provides the support software needed to generate, maintain, and test the SRCP. It consists of the following functional components:

- Program Generation Package (PGP) - provides the production of the SRCP tapes and maintenance of the radar program files. Includes the RDC assembler and loader.

- RDC Functional Simulator (RDCFS) - simulates the RDC processor and data transfer for active and passive I/O for testing the SRCP on the 370/155.

- Radar Data Generator (RDG) - generates realistic radar target and ECM detection data from a scenario input for exercising the SRCP.

- Special Test Programs (STP) - perform octal memory dump, instruction trace, and input simulation for testing the SRCP on the RDC.

The PGP, RDCFS, and RDG run on the IBM 370/155 ground support computer and are written mainly in FORTRAN. The STP operate directly on the RDC and are written in RDC assembly language.

4.3.1.3 Navigation Computer Program

The Navigation Computer Program (NCP) consists of two separate programs. One program resides in the Omega Navigation Equipment (ONE) with the second in the Inertial Navigation Equipment (INE). The INE/NCP, however, will not be covered in this report because the system will be maintained by DELCO (Carousel IV is used by systems other than E-3A). In this report, the term NCP will in most cases refer to the ONE/NCP which is resident in the Northrop NDC 1070 computer.

The NCP combines data received by the Omega receiver, inertial data, and Doppler velocity data in a Kalman filter to provide navigational data. The updated navigational data is used by the AOCP to accurately reset the dual INE.

4.3.1.4 Pre-Mission Readiness Computer Program

The Pre-Mission Readiness Computer Program (PMRP) operates as a stand alone program stored in mass memory and is loaded into the 4π CC-1 when required. It performs operational GO/NO-GO testing for the 4π CC-1 computer and other elements of the data processing functional group (excluding the IAU). Outputs from PMRP consist of failure indications on the Operator Control Panel (OCP) and a printed summary of system status, either a GO condition or a system NO-GO indication with failing unit(s) identified. There are separate versions of the PMRP for the DPFG and for the IAU.

4.3.1.5 Diagnostic Maintenance Program

The Diagnostic Maintenance Program (DMP) operates as a stand alone program stored in mass memory and is loaded into the 4π CC-1 when required. It provides for a detailed logic unit test with fault isolation of the elements of the DPFG in a pre-mission environment. Two separate areas are the data processing subsystem DMP and the IAU DMP.

4.3.1.6 System Maintenance Computer Program Fault Trees

The System Maintenance Computer Program (SMCP) resident in the 4π CC-1 operates in real time with and under control of the AOCP executive to provide in-flight operational maintenance.

The fault trees are part of the monitor and test subsystem control function of the SMCP. This SMCP function provides for performance monitoring, fault verification, and fault isolation of mission avionics hardware [DPFG, DDCFG, IFG, antenna phase controller, monitor and test subsystem (OBTM&M), and IAU (fault detection only)]. Fault trees consist of stored information (stored on the MTT) used to perform fault isolation. They include test steps, stored limits for isolation test points, and information on what to do if the test point passes or fails. The steps are continued until either a redundant element can be switched in or a specific repair instruction can be given to the operator.

4.3.2 Support System

4.3.2.1 Software Support

Responsibility for supporting the software programs that reside in the E-3A system's embedded computer (both airborne and ground-based) is shared between TAC and AFLC. The previous section has identified the individual CPCI's to be supported by each command. Of particular interest to this study are the six CPCI's for which AFLC/OC-ALC is responsible and the AISF they will use to assist them.

The AISF is defined as a collection of software support tools assembled in ground facilities for the purpose of performing the steps requisite to implementing changes in avionics computer programs. Existing plans call for it to be developed in two phases. The goal of Phase I is to establish a limited operational support capability for assigned software on core aircraft configurations by March 1983. The goal of Phase II is to provide a full software operation and support

capability for the core configured aircraft with a limited capability (surveillance radar and navigation systems only) for the Maritime (U.S. Standard) aircraft configuration. Plans call for Phase II to be completed by the first quarter FY 84.

The AISF will be comprised of equipment (available mainly from existing E-3A facilities and the aircraft avionic pipeline) integrated with minimal departure from those tools employed by the developing contractor during Full-Scale Development (FSD). Installation will be in a Tinker AFB facility specifically constructed for software support. In complying with AFR 800 series management policies, AISF acquisition will subscribe to a formal design cycle with attending configuration management procedures, design reviews, and audits.

Four primary elements will form the AISF: (1) the surveillance radar AISF module, (2) the navigation computer system AISF module, (3) the data processing subsystem AISF module, and (4) integration and interface special equipment, as illustrated in Figure 4-4 and described in Table 4-5.

When found to be feasible, government assets will be used to configure the four primary AISF modules. Identification of some of the key assets follows.

- DPS AISF Module. A significant amount of the equipment required for this module can be made available from the Software Development Laboratory at the Boeing Company's Seattle, WA facility. The remaining equipment will be acquired from item managers and through procurement of standard commercial equipment and services. This module will provide the capability to support the following CPCI's:
  - Pre-mission readiness computer program
  - Diagnostic maintenance computer program
  - System maintenance compute program fault trees
- SR AISF Module. The basic approach for developing this module is to copy the test stands employed by the radar contractor (Westinghouse). In-so-far as this is possible it should minimize the risks of a new design. Significant cost savings may result if all or portions of the surveillance radar system (No. 2001) located at the Westinghouse

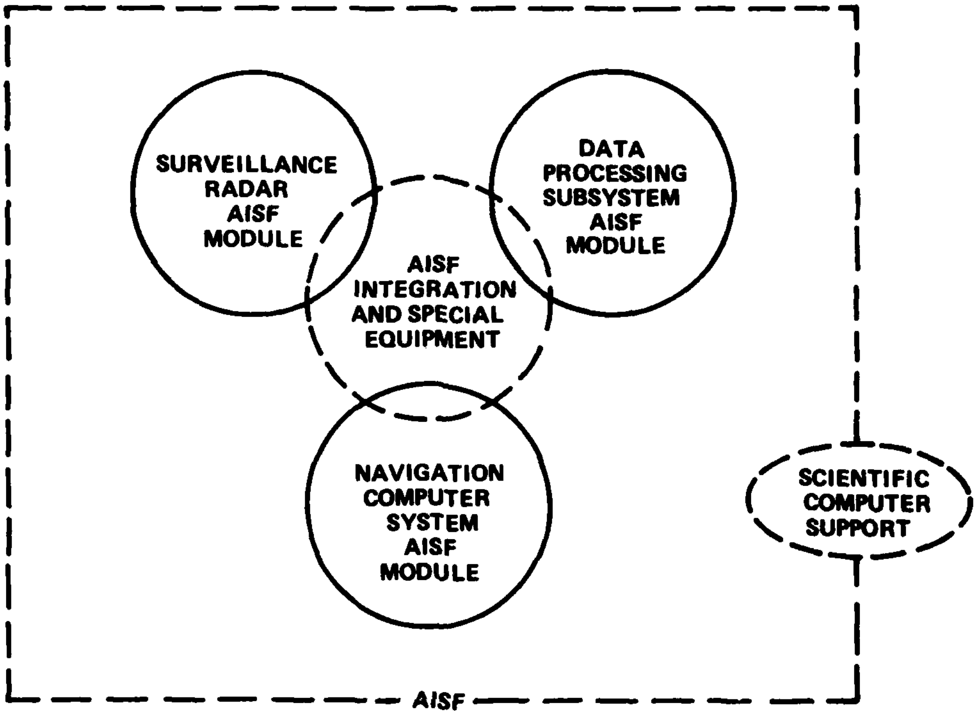


Figure 4-4. AISF Elements

Table 4-5. E-3A AISF Module Equipment/Capability Summary

Data Processing Subsystem (DPS) AISF Module	The DPS AISF module will in essence be a "hot mockup" of the E-3A airborne DPS equipment, containing the Electronic Subsystem Test Set Group (ESTSG), equipment from the Data Processing Functional Group (DPFG), Data Display Group, and the Interrogation Set. This equipment, plus special test and peripheral equipment to provide full system simulation, will enable the DPS AISF module to test and evaluate the Diagnostic Maintenance Programs (DMP's), the Pre-Mission Readiness Program, and the System Maintenance Computer Program (SMCP) fault trees for the Block 01 aircraft configuration. The design of the Data Processing AISF module will be based on the design of the Software Development Laboratory currently in use by the Boeing Company.
Surveillance Radar (SR) AISF Module	The SR AISF module will consist largely of AN/APY-1 airborne Westinghouse radar equipment (minus the dome rotary joint and antenna radiator sticks), and special equipment and adaptations to facilitate data acquisition, diagnostic testing, etc. involved in software O&S, affording a capability to test and evaluate the OC-ALC assigned Surveillance Radar Computer Program (viz the DPAC/FD and BIT/FLT software) for the dual Block 01/05 aircraft configuration. The Surveillance Radar AISF module design will be based on the Westinghouse software test stand.
Navigation Computer System (NCS) AISF Module	The NCS AISF module, in providing a system level capability to test and evaluate changes to the Omega Navigation Computer Program, as well as a tool for the rapid solution of "on-aircraft" problems on Block 01/05 configured aircraft, will be made up of E-3A airborne equipment and augmented by special test and simulation equipment to aid in software code, debug and test activities. The design of the Omega/Navigation module will be based on the design currently in use by the Naval Air Development Center (NADC) and supplemented to provide inertial navigation integration.
System Integration	The AISF integration and special equipment, comprised principally of cabling, simulations, and other special test equipment will insure compatibility between the three baseline modules while providing an integrated E-3A system level capability to conduct end-to-end functional operations with interrupts and breakouts as necessary for special tests and analysis. The design of the integrated system will be based on the operational/aircraft as feasible.
Scientific Computer Support	The IBM 370 managed and operated by the 552nd AWAC Wing will be used to satisfy off-line scientific batch type computing requirements which accompany the AISF.

facility in Baltimore, MD can be used. Some of the components and subassemblies of this system can be used to develop the Radar Software Bench (RSB). The RSB represents the first stage of the SR AISF module. It is scheduled to be operable by September 1981.

The second stage of the development incorporates the remaining components and subassemblies for radar system 2001 including those components previously supporting enhancements such as the Spectral Control Feature (SCF). This composite bench (core configuration) is scheduled for operation by January 1983.

The third stage of development provides a dual configuration bench (Core/Maritime) by July 1984. The additional equipments for this stage can be provided from Kit No. 3 of the Maritime Surveillance Capability (MSC) development activity.

The SR AISF module will provide the capability to perform software investigation/analysis of the Detection Processing and Control (DPAC) portion of the surveillance radar computer program plus initial support of the Fault Detect (FD). Special Test(ST) portion of the surveillance radar equipment. The support of the Fault Isolation Test (FIT) portions of the SRCP will be limited during Phase I.

- NCP AISF Module. This module consists of an Omega receiver computer (NDC 1070) and an Inertial Navigation Unit (Carousel IV) configured to accurately simulate the E-3A navigation system. An HP 2113 minicomputer provides the trajectory and interface functions necessary to create a real time operational environment. Acquisition of this module will be as indicated by the following activities: (1) commercial equipment (standard peripherals) will be acquired under the auspices of the Naval Air Development Center (NADC) to acquire equipment required for NCS software support during full-scale development/production, (2) E-2A peculiar avionic equipment will be obtained through the AFLC Item Manager (IM), and (3) necessary switching capability and cabling will be acquired through NADC from separate vendor contracts. NADC personnel will assist OC-ALC personnel to install, integrate, and initially check out the NCS AISF module.

- AISF Integration and Special Equipment. The DPS Module, the SR Module and the NCS Module need to be integrated and interconnected to produce an integrated software support facility. The special test equipment cabling, interface units, and so forth that are required will be procured from item managers if possible or from commercial sources, if necessary.

4.3.2.2 Hardware Support

The maintenance concept to be utilized for the E-3A AISF equipment will depend on whether it is on-board avionic equipment, commercially available equipment, or E-3A AISF unique equipment.

The E-3A AISF equipment which is identical to the equipment on-board the E-3A aircraft will be maintained as if it were another aircraft with spare part support provided by the appropriate item manager. The same maintenance procedures exercised on the E-3A aircraft itself will be employed. Existing test equipment provided for maintenance of the E-3A at the MOB (TAFB) will be used with maintenance assistance provided by TAC as required.

Commercially available peripheral equipment used in the E-3A AISF will be supported through maintenance contracts with the manufacturer. However, in certain cases it may prove cost effective to directly procure spares and perform organic maintenance.

Equipment unique to the E-3A AISF will be supported by maintaining a special supply of spare parts purchased from the vendor and utilizing organic maintenance technicians. Spare parts in this regard will be ordered and maintained in accordance with the procedures established for engineering test lab equipment acquisition.

4.3.3 Support Posture Evaluation

The E-3A AWACS CPCI's are to be supported by two commands, TAC and AFLC. TAC's software support facility has been operational for some time and is currently supporting the CPCI's that have been assigned to TAC. AFLC's OC-ALC is currently in the early stages of developing an AISF to support the CPCI's that have been assigned to AFLC.

The TAC facility supports the E-3A's Airborne Operational Computer Program (AOCP) which resides in the aircraft's IBM 4π CC-1 central computer. The TAC facility also will support several airborne and ground-based support and test computer programs when completed. The OC-ALC ISF will support the airbone surveillance radar program, the airborne Omega navigation program, and several support and test computer programs.

If the OC-ALC E-3A AWACS AISF is completed as currently planned, it will provide a capability sufficient to support the AFLC assigned CPCI's. The software change procedures for these computer programs relative to initiating change requests, screening and reviewing requests and recommended fixes, conducting development and operational tests, and distributing CPCI changes are discussed in detail in the O/S CMP. However, the critical OC-ALC and TAC interfaces are not clearly defined in the O/S CMP. The primary emphasis of the current O/S CMP is on TAC change procedures. AFLC change procedures should be strengthened in the next revision of the O/S CMP.

Table 4-6 presents an assessment of the adequacy of the planned E-3A AWACS support posture when compared to the ECS support requirements presented in Section 2. The comments are grouped into the same six functional areas in which Section 2 has grouped the support requirements.

4.4 JOINT SURVEILLANCE SYSTEM

4.4.1 System Description

The Joint Surveillance System (JSS) is presently being developed to replace the SAGE/BUIC system. The U.S. and Candian mission of peacetime air surveillance and control of sovereign air space within the Continental United States (CONUS), Alaska, and Canada will be accomplished by JSS. For Canada, the mission is expanded to include support of wartime air defense functions, and in Alaska the mission includes the performance of tactical air control functions.

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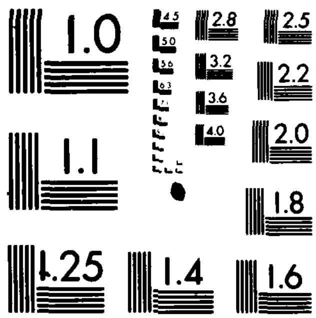

MICROCOPY RESOLUTION TEST CHART
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Table 4-6. E-3A AWACS Support Posture Status

Support Requirements	Findings/Remarks
ECS Change	The E-3A AWACS CPCI's are to be supported in part by TAC and in part by OC-ALC. Thus, when a change request is initiated by the user organization it must first be ascertained by the AWACS CPCSB whether TAC or OC-ALC will be the responsible organization. At present time only the TAC facility is operational; therefore, any changes for which AFLC would normally be responsible are presently handled by the SPO/contractor team.
Change Analysis and Specification	The change analysis and review procedures are clearly defined in the O/S CMP for TAC supported CPCI's, however the AFLC review process is not clearly defined. The current CRISP and O/S CMP should be reviewed and updated.
Engineering Development and Unit Test	The currently operational TAC software support facility at Tinker AFB provides the capability required to integrate changes to the CPCI's for which TAC is responsible. The facility will also support development testing. CPCI changes for which AFLC is to become responsible at PMRT are, at present, handled by the SPO with contractor support in contractor facilities.
System Integration and Test	Both the existing TAC facility and the upcoming OC-ALC ISF will support the total integration and partial operational testing of E-3A CPCI changes. It is quite likely that complete verification of software changes will not be signed off until the E-3A aircraft has participated in a flight test of the changes.
Change Documentation	AFR 800-14 prescribes that CPCI's and related documentation be assigned a CPIN number. TAC uses a unique Software Change Report (SCR) number to identify each CPCI. Both TAC and OC-ALC will share the responsibility, as appropriate, for maintaining and updating the E-3A AWACS software. The joint TAC/OC-ALC configuration management interfaces should be more clearly defined and strengthed in the O/S CMP. The last O/S CMP revision was in May 1978.
Certification and Distribution	The using command change distribution procedures are defined in the O/S CMP. The relationship between these procedures and TCTO distribution procedures required in AFR 800-14 for AFLC are not clear. This relationship should be spelled out in an O/S CMP revision.

The JSS is composed of three major and unique components. These are seven individual Region Operations Control Centeres (ROCC's), an initial complement of 86 radar sensor sites distributed between the ROCC's, and one System Support Element (SSE).

4.4.1.1 Region Operations Control Centers

Seven ROCC's will provide the command, control, communications, and surveillance functions for JSS. Each will include Automatic Data Processing Equipment (ADPE), software, displays, and communications necessary to sustain these functions. Four ROCC's will be operated by Aerospace Defense Command (ADCOM) and located in the CONUS; two ROCC's will be operated by the Candian Forces and located in Canada; and one ROCC will be operated by Alaskan Air Command (AAC) and located in Alaska.

4.4.1.2 Sensors

Initially, the 86 sensor sites in CONUS, Alaska, and Canada will provide automated surveillance data and in most cases height and beacon data to the ROCC's. The system will allow as many as 140 sensor sites to be tied. The sites will contain the communications necessary for the command and control of interceptor aircraft.

There will be 45 sensor sites in the CONUS of which 31 will be joint FAA/USAF sites, seven will be USAF only sites, one will be joint USAF/Navy, five will be FAA data-tie sites (providing search and SIF data only), and one will be an aerostat borne radar (SEEK SKYHOOK).

Initially, there will be 14 sensor sites in Alaska, one of which will be FAA owned. Two sites will provide data to a ROCC and the FAA ARTOC; the remaining twelve will be AAC sites providing data to the ROCC. Current planning for future expansion of radar coverage in Alaska may increase the number of sensor site inputs to a total of 17 with a potential for 20.

Initially, 24 existing Canadian sites will provide data to two ROCC's and to the Ministry of Transport Joint Enroute Terminal System Control Centers. Current planning involves the replacement of the existing 24 radars with up to 40 new type radars. Canadian participation in JSS is limited to the joint US/Canadian acquisition of ROCC's and associated training and support.

4.4.1.3 System Support Element

The System Support Element (SSE) segment will support all ROCC/SSE military-owned computer hardware and software, displaced Southeast ROCC Operations capability, and training of USAF/CF operations and maintenance personnel as directed by HQ USAF and NDHQ. The SSE segment shall consist of two subsegments: an ROCC System Support Facility (RSSF) subsegment whose mission will be software oriented and a System Hardware Support (SHS) subsegment whose mission will be hardware oriented. These two subsegments shall include the following functional areas:

- ROCC System Support Facility (RSSF) subsegment

  Computer Program Functional Area (SCPFA)
  Data Processing and Display Functional Area (SDPDFA)
  Communications Functional Area (SCFA)
  Support Functional Area (SSFA)
  Facilities Functional Area (SFFA)

- System Hardware Support (SHS) subsegment

  Computer Program Functional Area (HCPFA)
  Data Processing and Display Functional Area (HDPDFA)
  Communications Functional Area (HCFA)
  Support Functional Area (HSFA)
  Facilities Functional Area (HFFA)

4.4.1.4 Computer Resources

The computer resources within a JSS ROCC consist of the multiple computer and associated peripherals shown in Figure 4-5. The figure illustrates the ROCC's configuration contains two complete and

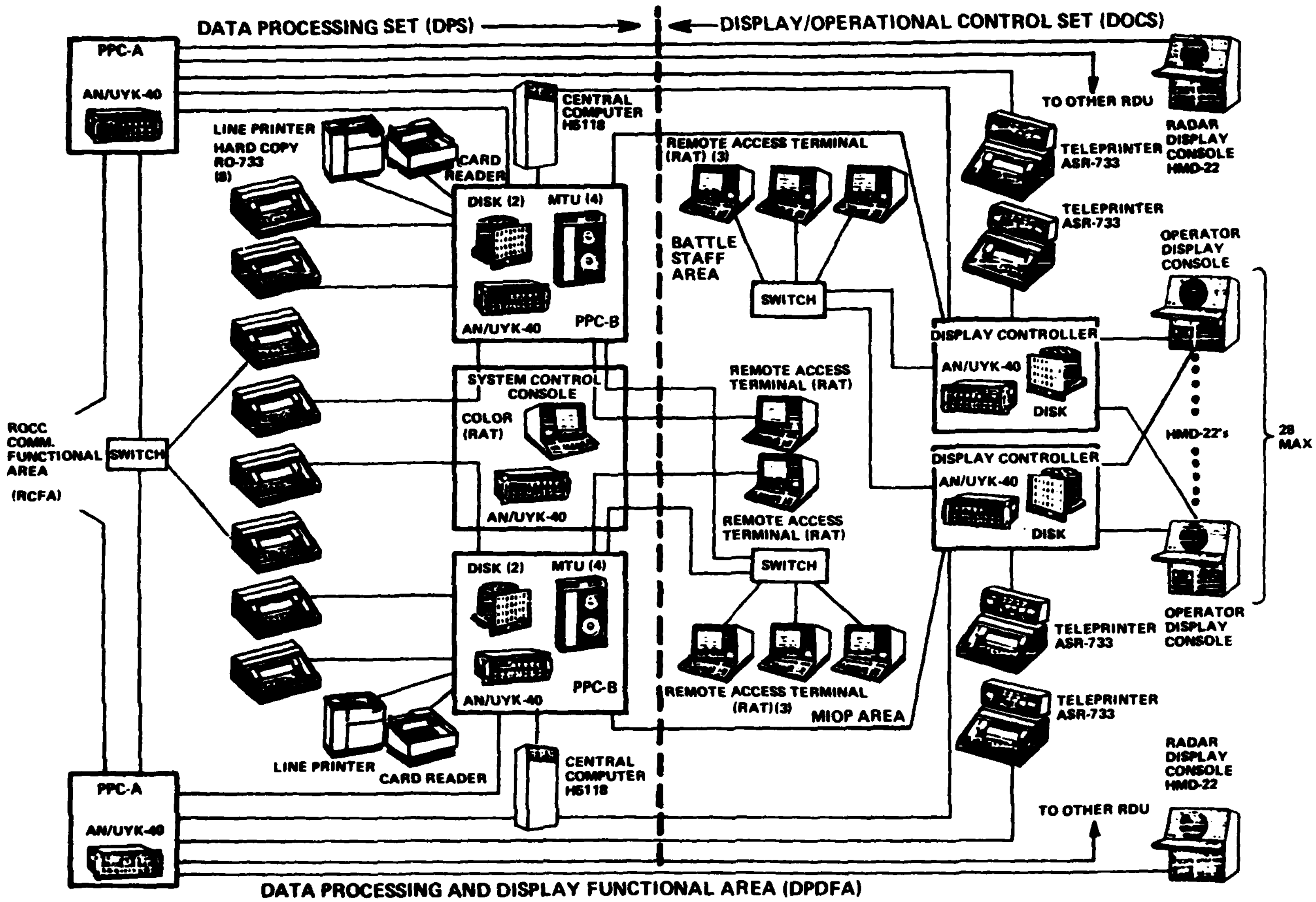


Figure 4-5. ROCC Configuration

complementary threads (or paths) from the ROCC Communication Functional Area (RCFA) through the Data Processing and Display Functional Area (DPDFA) to the operator display consoles. In effect, the top half of the figure represents one complete data processing and display path, while the lower half represents a second complete path. Each of the two threads through the ROCC configuration includes four computers. The Central Computer (CC) is a Hughes H5118, the Programmable Peripheral Computer A (PPC-A) is an AN/UYK-40, the PPC-B is also an AN/UYK with two disks and four MTU's, and the Display Controller (DC) is also an AN/UYK-40 with one disk. In addition, the system control console which is shared by each of the two threads includes one more AN/UYK-40. The system's operator display consoles do not include an embedded digital computer, but they do include five different types of Printed Circuit Boards (PCB's), each with multiple PROM's. These boards are classified as dynamic firmware and must also be supported by the Software Support Element (SSE).

As mentioned in Section 4.4.1.3, the Software Support Element (SSE) contains an RSSF subsegment whose mission is to provide software support and a SHS subsegment having a hardware oriented mission.

The RSSF is to be collocated with the Southeast (SE) ROCC at Tyndall AFB, FL. Three major activities shall be performed by this RSSF. The first is software support for all seven ROCC's and the complete SSE. The second is to act as a displaced SE ROCC when required. The third is to support the positional training of ROCC operators.

The SHS has two major activities. The first is to provide hardware maintenance training while the second is to support kit proofing.

Because the RSSF must, at times, operate as a displaced SE ROCC it must have the same operational computer program CPCI's as the seven ROCC's will have. Thus, the RSSF CPCI's described below include the ROCC CPCI's.

4.4.1.4.1 RSSF Operational CP CPCI's

- Operating System Set (OSS) - shall include all computer programs required for operations control task management, recover, input/output control, and system confidence necessary to perform the RSSF mission.

- Applications Set (APS) - shall include all computer programs required to execute and control real time Displaced Southeast ROCC Operations (DISROP) for the southeast region.

- Display Control Firmware (DCF) - computer program shall support efforts to reprogram the PCB's in the operator display consoles.

4.4.1.4.2 RSSF Support CP CPCI's

- Support Set (SUS) - shall include all computer programs required for language processing, utility functions, and data reduction necessary to support the RSSF missions.

- System Exercise Set (SES) - shall include all computer programs necessary for the generation, editing, and review of non real time simulation data. This capability shall provide for the generation of large scale multi-region NORAD exercise files.

- Diagnostic Set (DIS) - shall include all computer programs required to support fault isolation for equipment in the RSSF data processing and display functional area and selected equipment in the RSSF subsegment communications functional area.

- Data Reduction Set (DRS) - shall include all computer programs required to support data reduction and system evaluation activities.

- System Control Set (SCS) - shall include all computer programs required to support system control activities.

4.4.1.4.3 SHS Operational CP CPCI's

- Operating System Set (OSS) - shall include all computer programs required for task management, resource management, input/output control,and on-line fault detection necessary to perform the SHS mission. Except where limited by equipment configuration,this set should be identical to the ROCC OSS.

- Applications Set (APS) - shall include all computer programs required to support the diagnostic capability of the ROCC Diagnostic Set for hardware maintenance training and kit proofing. It shall also provide for the use of the on-line confidence checking capability for training purposes. Except where limited by equipment configuration, the operation and performance of the on-line confidence checking capability in the training environment of the SHS shall be identical to that of the ROCC Applications Set.

4.4.1.4.4 SHS Support CP CPCI's

- Diagnostic Set (DIS) - shall include all computer programs required to provide for the use of the off-line fault detection and fault isolation capabilities for training purposes. Except where limited by equipment configuration, the operation and performance of the off-line fault detection and fault isolation capabilities in the training environment of the SHS shall be identical to that of the ROCC diagnostic set.

4.4.2 Support System

4.4.2.1 Software Support

Software support for all the software CPCI's that execute in the various computers of the ROCC will be accomplished by the RSSF subsegment of the SSE. Since the RSSF must also operate as a displaced SE ROCC for a portion of each month, it must have a similar hardware and software configuration. Section 4.4.1.4 indicated that the ROCC configuration, in effect, has two identical threads through the system (see Figure 4-5). The RSSF complement of hardware includes equipments that are identical by type to those in either thread of an actual ROCC, but not identical by number. For example, the RSSF will have only 11 operator display consoles while the ROCC will have 14 in each thread. The specific number of each equipment type that constitutes the total RSSF configuration is listed in the JSS CRISP (Appendix D3 and D4) and will not be repeated here.

The RSSF will be required to support three major activities. The first is software support which shall be shared with the SE ROCC. The RSSF shall be manned and equipped to provide all software support required by the seven ROCC's and the SSE. This shall include the capability to design, modify, and test computer programs. It shall also include the capabilities to support storage media (e.g., magnetic discs and tapes), documentation, a computer program support library, generation of exercise files for both single region and multi-region exercises, and replaying an event after the fact.

The second activity is Displaced Southeast ROCC Operations (DISROP). The DISROP activity shall be activated when it becomes necessary to use the SE ROCC resources to support certain system capacity and operational ROCC software test and evaluation activities. Under these circumstances, SE ROCC operations personnel shall relocate temporarily to the RSSF and conduct DISROP using RSSF capabilities. The requirement to use SE ROCC resources for system testing shall be minimized. It is anticipated that no more than 36 hours per month of the SE ROCC operating time will be used.

The third activity is training. One of the most important training activities shall be positional training of ROCC operators. This shall be ROCC oriented training for operational personnel who have completed basic Air Training Command courses. Operator training will be shared with the SE ROCC as determined by operational procedures. Training will include computer operators (CpOp) and computer programmers. Selected portions of computer operator training may be at the SHS subsegment or the RSSF. Training may be accomplished on equipment mockups if the mockups meet training requirements.

The operational and support CPCI's that will execute in the RSSF's computers have previously been identified in Sections 4.4.1.4.1 and 4.4.1.4.2.

4.4.2.2 Hardware Support

Hardware support of ROCC equipment will be accomplished by the SHS subsegment of the SSE. The SHS will support the training of hardware maintenance personnel and kit proofing. The maintenance personnel will be trained in the use of ROCC/SSE off-line/on-line diagnostic computer programs. Kit proofing shall include hardware modifications to ROCC/RSSF equipments and shall include verification of equipment operation and maintenance technical orders and changes thereto. Equipment kit proofing, modification acceptance testing, and technical order verification will be conducted by Air Force Logistics Command, NDHQ, and the using agencies. If communications equipment is bought rather than leased, then communications maintenance training may be located at the SHS subsegment.

The operational and support CPCI's that will execute in the SHS's computers have previously been identified in Sections 4.4.1.4.3 and 4.4.1.4.4.

4.4.3 Support Posture Evaluation

The JSS RSSF is to be located at a JSS operational site, the ROCC at Tyndall AFB, FL. As a support facility it is unique that it will also serve as a back-up ROCC and, in addition, will be used as a training device for operational and maintenance personnel. The RSSF is still in the development stage; however, when it is completed it will be able to support all of the JSS CPCI's. ADCOM (ADTAC) configuration control procedures as outlined in AFR 800-14 (Volume II) and ADCOMR 55-111 will be followed during the software change process in order to maintain a well-controlled baseline. These procedures will be defined in the O/S CMP when it is written. The draft CRISP establishes the O/S CMP as the principal source document for change control.

Table 4-7 presents an assessment of the adequacy of the planned JSS support posture when compared to the ECS support requirements presented in Section 2. The comments are grouped into the same six functional areas in which Section 2 has grouped the support requirements.

Table 4-7. JSS Support Posture Status

Support Requirements	Findings/Remarks
ECS Change	Operational CPCI will be supported by ADTAC (formally ADCOM). The static firmware will be supported by SM-ALC. The resources required to support ADTAC tasks are adequately described in the CRISP; however, resources required to support the SM-ALC assigned responsibilities are not specifically identified.
Change Analysis and Specification	The current CRISP does not require AFLC participation in the change analysis process for ECS software or dynamic firmware. Static firmware change procedures are not presented in the CRISP.
Engineering Development and Unit Test	See above.
System Integration and Test	The JSS RSSF configuration is comprised of components that are identical to those in an actual operational site and, as well, duplicate a complete processing thread through a site from the communications interface to the operator display consoles. Thus, the facility is capable of achieving 100 percent verification of CPCI changes.
Change Documentation	The document and configuration management requirements are called out in the draft CRISP. This document and the O/S CMP, when it is written, will act as a configuration control MOA between the employing and supporting commands. Specific documentation procedures will be spelled out in the O/S CMP
Certification and Distribution	Basic requirements have been established in the draft CRISP, however, more detailed procedures should be included in the O/S CMP.

4.5 JOINT TACTICAL INFORMATION DISTRIBUTION SYSTEM

4.5.1 System Description

The JTIDS program capitalizes upon the experience and technology established through previous developments of the individual services both in-house and within industry. The program was established to converge previous and on-going efforts into a common joint service capability. This is possible, since standardization of the JTIDS pulse, RF, and coding characteristics has made all JTIDS development efforts complementary and has established multiple sources within industry for most of the critical long-lead hardware and software elements. A secure data unit is being developed and procured by the National Security Agency for use with all JTIDS terminals. A common JTIDS language, TADIL J, is being developed by the Joint Interoperability of Tactical Command and Control Systems (JINTACCS) program. The JTIDS program is designed to develop and acquire a time division multiple access, secure, jam-resistant, low intercept potential, digital information distribution system with relative navigation, and positive user identification capabilities suitable for use by all services. JTIDS is planned to be used within a mix of alternative communications resources to interconnect the tactical and air defense elements of all services including surface and airborne command, control, surveillance and intelligence centers, ships, and combat and support aircraft.

Four types of terminals are eventually envisioned for the total system. Brief descriptions follow.

4.5.1.1 Class 1 Terminal

This terminal is being developed by Hughes Aircraft and is often referred to as the Hughes Improved Terminal (HIT). It is a high powered terminal for use in large platform aircraft (e.g., E-3A), ships, and ground tactical communications systems. The HIT (AN/URQ-31)

is a terminal consisting of both hardware and computer program software which will provide the capability for any equipped platform to participate in the JTIDS. The terminal provides the capability to transmit in assigned time slots within the network structure and to receive in all time slots not used for transmission. The HIT operates in a frequency band between 960 and 1215 MHz with a maximum range of 500 nautical miles.

A relative navigation capability is being developed for potential use by Class 1 equipped systems. This effort is a software modification to the basic HIT computer program. Relative navigation will provide the user with geodetic and relative navigation capabilities with high accuracy. In addition to software modifications, hardware additions will be required to interface the HIT terminal software with the particular platform to be installed.

4.5.1.2 Class 2 Terminal

The Class 2 Terminal is a smaller, lower powered version of the Class 1 Terminal designed for space limited platforms such as flighter aircraft (e.g., F-16 and small ships). The Class 2 Terminal will also have an integrated tactical air navigation and relative navigation capability. The Class 2 Terminal is currently in the source selection process and will not be discussed in any detail in this section.

4.5.1.3 Class 3 Terminal

The Class 3 Terminal will be a low cost, compact terminal intended for guided missile control, manpacks, ground vehicles, and similar applications. It is still in a very early concept formulation stage.

4.5.1.4 Adaptable Surface Interface Terminal

This fourth terminal, the ASIT, will provide a transparent interface with existing ground command and control systems. It provides a jam resistant communication link between JTIDS users. The ASIT

program is developing unique hardware and software along with incorporating a GFE Hughes Improved Terminal (HIT) with an IBM ML-1 translator/processor. This terminal will convert the TADIL B message standard of the host platform/system into JTIDS Interim JTIDS Message Specification (IJMS) and vice versa. IBM is currently under contract to develop this terminal.

The computer resources within the JTIDS system consist of the digital computers and their associated CPCI's that are embedded in the JTIDS terminals. The Class 2 and Class 3 Terminals are not included below for previously stated reasons.

4.5.1.5 E-3A/HIT, Class 1 Terminal

The heart of this terminal is a Hughes HMP 1116 16-bit mini-computer modelled after the Interdata 7/16 minicomputer. For its E-3A application it will have two operational CPCI's. The first of these is the E-3A/HIT Operational Computer Program (OCP). This program provides the interface between the E-3A and the JTIDS network. The second CPCI is the HIT Fault Isolation Software (FIS). The FIS program is used to isolate problems within the terminal equipment.

4.5.1.6 Adaptable Surface Interface Terminal

This terminal incorporates a complete HIT and an IBM ML-1 translator processor computer. There are four CPCI's associated with the two computers. The ASIT HIT has its own unique OCP. This program, referred to as the ASIT Communications Equipment (ACE) OCP, has some common sub-programs with the E-3A/HIT OCP (about 45 percent), but the remainder is distinctly different. A second ACE OCP is also to be developed. This OCP will incorporate a RELNAV modification to the original ACE OCP to allow the ground-based ASIT to know the precise location of each E-3A on its net. The third CPCI is the OCP for the ML-1 computer. This TP OCP resides in the ML-1 and controls the ASIT subsystems for translation of JTIDS

messages to TADIL-B and vice versa. The fourth CPCI that executes in the ASIT is the TP FIS program. This program resides in the ML-1 and is used to isolate problems within the terminal equipment.

4.5.2 Support System

The JTIDS computer resources support system encompasses multiple organizations and two distinct time periods. Prior to PMRT, the support responsibility has been delegated by AFSC to the JTIDS Joint Program Office under the Deputy for Communications and Information Systems, at ESD. During this time period all changes to CPCI's will be implemented by the individual contractors using their own in-house development facilities. Post-PMRT will find AFLC/WR-ALC responsible for both the HIT and ASIT computer resources with the following exception. A current MOA between TAC and AFLC has assigned support responsibility for the ASIT/TP OCP CPCI to TAC, Langley AFB.

During the post-PMRT time period, it may be necessary to coordinate a software change with the 552nd AWACS Wing at Tinker AFB. This situation could arise if a proposed change to a CPCI residing in the E-3A HIT affected the interface between the E-3A HIT and the E-3A on-board IBM 4π CC-1 computer. In a similar manner, TAC/Langley could be involved if a proposed change affected the ASIT to TACS/TADS interface. As a result of these complexities it is apparent that the proper configuration control of proposed changes is a difficult problem. Currently, no set of procedures has been defined. The JTIDS draft CRISP(s) have not yet been coordinated and signed. Furthermore, the JTIDS O/S CMP which will detail the interfaces and CM procedures has yet to be written. Thus, any specific discussion of CM procedures must be deferred. On the other hand, significant progress has been made in terms of designing the ISF that will be developed at WR-ALC to provide a means for implementing software changes. The following section will describe the ISF concept in some detail.

4.5.2.1 Software Support

WR-ALC/MMEC is developing an implementation plan for acquiring an ISF to be used in supporting the JTIDS CPCI's assigned to WR-ALC. The ISF consists of a number of computer based simulators, several actual operational terminals (both HIT's and ASIT's), additional off-line computing equipment, and other support equipment. In addition to the ISF's hardware there is a substantial amount of operational, support, and test software to be developed. The following sections will describe both the ISF equipment and software programs in some detail.

4.5.2.1.1 ISF Description. Figure 4-6 is presented to illustrate the functional configuration of the WR-ALC ISF. At the present time, the only planned application for the Class 1 HIT terminal is the E-3A while the only current application of the ASIT terminal is the TACS/TADS system. Thus, as key elements, the WR-ALC ISF will contain both a TACS/TADS simulator and an E-3A simulator. The figure also indicates the functional layout of the Langley AFB facility and the E-3A AWACS facility at Tinker AFB, as well as their interconnectivity. This interaction will enable testing of some JTIDS capabilities which a single facility is incapable of performing. It will allow the use of the facilities during Follow-on Testing and Evaluation (FOT&E) after initial software turnover. This land line link will utilize the capabilities presently existing in the ASIT to pass data from one facility to another.

The functional role played by each of the major elements of the WR-ALC ISF and the other two facilities follows.

- JTIDS System Exerciser (JSE). This device was initially developed to support the Initial Operational Test and Evaluation (IOT&E) tests of the Adaptable Surface Interface Terminal (ASIT). It is capable of generating or recreating scenarios, fully loading the net, and providing a dynamic operator interface to the net during operation. The JSE incorporates a HIT in which either the E-3A/HIT OCP or the ACE OCP can be executed, depending upon which one is desired for the test being conducted.

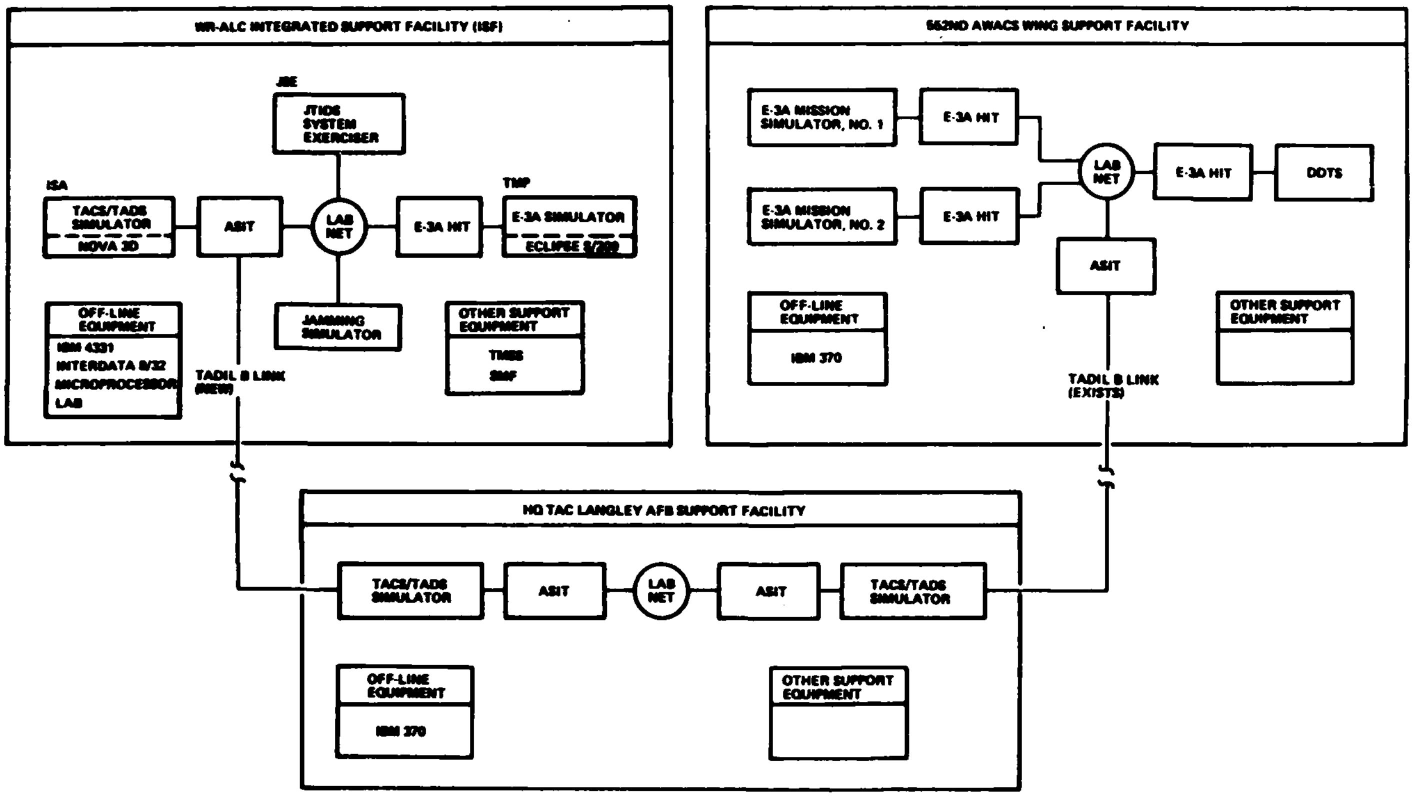


Figure 4-6. JTIDS Integrated Support Facility (ISF)

- <u>TACS/TADS simulator.</u> This device will be used to exercise the ASIT in a TACS/TADS environment. The simulator is basically a protocol and message traffic simulation device. It also has a scenario generator with which it will be possible to recreate actual failure conditions.

  The WR-ALC implementation of this device is called the Interface Simulation Analyzer (ISA). It is hosted in a Data General NOVA 3D minicomputer. The simulator will provide the means to support the ASIT Bus Interface Module (BIM) firmware and ensure the interoperability of the ASIT with the JTIDS net. The TADIL B land lines will provide the TADIL B message traffic to the ASIT surface subscriber interface. This will provide means for live validation and verification of any changes to the firmware in the BIMS.

- <u>E-3A simulator</u>. This device is hosted in a Data General Eclipse S/200 minicomputer. Basically a message protocol and data flow simulator, the E-3A simulator also has a scenario generator which allows the creation of alternate testing conditions. It will be functionally similar to the device developed by the E-3A contractor to use in performing acceptance tests of HIT terminals received from the HIT contractor. WR-ALC's implementation of this device is called the TDMA Message Processor (TMP). It will support electrical testing of the hardware interface between the on-board HIT and the rest of the E-3A system. It will also support operational testing of the software interface between the HIT OCP and the Data Analysis Programming Group (DAPG) software package that resides in the E-3A's on-board central computer (IBM 4π CC-1).

- <u>Jamming simulator.</u> This device will be required on a day-to-day basis when developing new enhancements or correcting problems. Therefore, a small jammer simulator will be required in the lab for continuous interfacing. Before a block change or enhancement may be released to the field, it must be verified against enemy EW capabilities as simulated by this device.

- <u>Lab net.</u> The lab net is expected to be a coaxial type of interface to eliminate RF radiation inside the facility.

- Other support equipment. There are two other key support elements. The first is the test and maintenance support station. It functions as a test and simulation device for the HIT Transceiver Processor Unit (TPU). It also provides an operator the flexibility to perform the following operations with a bench-mounted TPU or with TPU's installed in HIT racks.

  - TMSS self-test diagnostics are used to verify the operational status of the TMSS HMP 1116 computer and the associated peripherals. The diagnostics are loaded from the Magnetic Tape Unit (MTU) into the HMP 1116 and include HMP 1116 memory, processor and serial channel tests, and peripheral tests for the line printer, card reader, I/O terminal, and MTU.
  - The Communications Processor (CP) of the TPU can be tested using the same HMP 1116 or the PTU CP to the expansion chassis and, thus, to the peripherals. A Processor Maintenance Panel (PMP) provides access and control of the CP and allows the processor and memory diagnostics to identify faults in the CP.
  - Terminal and network simulation and demonstration can be conducted using the TMSS as a signal processor simulator with special software.

  The second is the Software Maintenance Facility (SMF). The primary purpose of this HMP 1116 hosted facility is to provide the support and diagnostic programs necessary for the development and maintenance of the E-3A/HIT OCP. In conjunction with support software, the SMF provides to the operator the following functions:

  - SMF self-test diagnostics which will be used to verify the operational status of the HMP 1116 computer and the associated peripheral equipment
  - Software program development and assembly
  - Software program editing and debugging
  - Load tape generation
  - Test data reduction

- Off-line equipment. WR-ALC's ISF will have three computers that operate in an off-line mode in their support role. They are an IBM 4331, an Interdata 8/32, and a microprocessor support lab.

- <u>Langley AFB facility.</u> Langley is the location of the Tactical Systems Interoperability Support Center (TSISC). This gives them the capability of simulating two TACS/TADS elements with full capabilities. This simulation capability has a two-fold purpose. The first is to support the TACS/TADS elements' software and the second is to support the Joint Interoperability Tactical C^3 Systems (JINTACCS) interoperability testing. Through the JTIDS TAC/AFLC memorandum of agreement the Langley facility is tasked with supporting the ASIT Translator Processor OCP (TPOCP).

  The two TACS/TADS element simulators already exist as does the off-line support computer, an IBM 370. Therefore, the only additional elements required for supporting the ASIT TPOCP and the associated JINTACCS interoperability testing are two ASIT's complete with HIT's, a coaxial net interface, and land line interfaces to other facilities for FOT&E.

- <u>552nd AWACS Wing facility.</u> This facility exists and is used to support the E-3A mission software. A JTIDS addition to this facility is required to ensure that changes and enhancements to the JTIDS terminal are compatible with the E-3A interface changes and enhancements. The ASIT provides a land line link to the Langley facilities for JINTACCS testing as well as for FOT&E uses.

  To support this testing, HIT's are required to interface the mission simulators and the trainer (DDTS) to the coaxial net. The ASIT terminal is required to establish the land line link to the Langley facility for JINTACCS interoperability testing and FOT&E uses.

4.5.2.1.2 <u>Software Program Descriptions.</u> As is the case with many C-E systems, the software programs associated with JTIDS can be grouped into three categories. These are operational software, support software, and test software. The software programs within each of these three categories are described in the following paragraphs for both the Class 1 HIT terminal and the ASIT terminal.

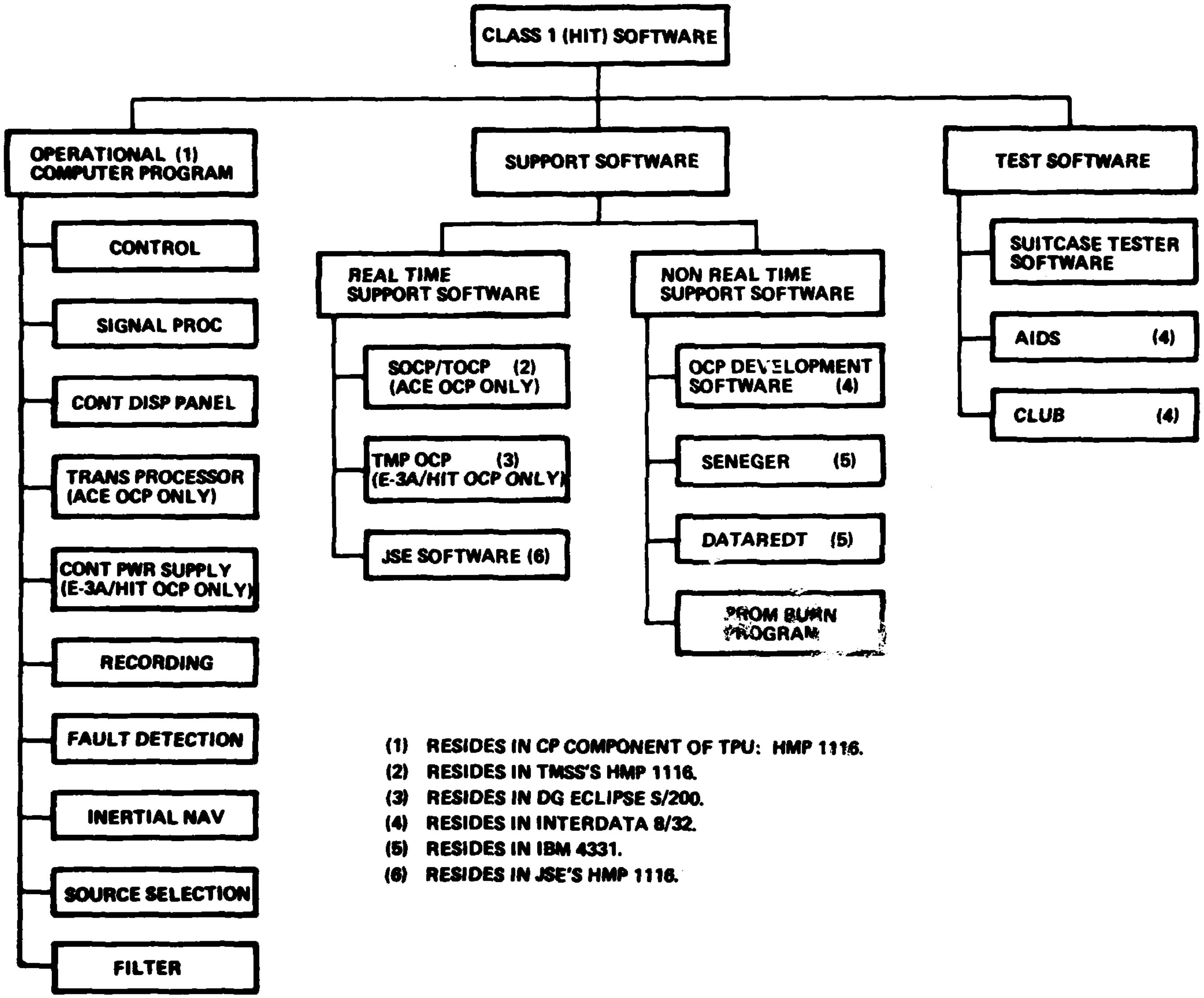
Class 1 (HIT) Software Description.

HIT Operational Software. The Class 1 (HIT) software is comprised of three distinct functional categories: Operational Computer Program (OCP), support software, and test software. These categories are depicted in the HIT software classification tree of Figure 4-7.

The HIT OCP is the computer program which resides in the Communication Processor (CP) component of the Transceiver Processor Unit (TPU). The TPU is the heart of the HIT and serves to control the HIT subsystems and peripherals. There are two versions of the HIT OCP. One is called the ASIT Communication Equipment (ACE) OCP which resides in the HIT used with the ASIT for ground sites. The other is the E-3A/HIT OCP which resides in the HIT used on the E-3A aircraft.

The principal operational capability of the HIT OCP is to establish, maintain, and control communications between the user interfaces and the Joint Tactical Information Distribution System (JTIDS) network. The JTIDS network consists of one or several nets (multi-net) with one terminal operating in master mode for all nets and one or more terminals operating in normal, polling, or radio silent modes, as participants.

The establishment of communication between the user terminal and the JTIDS network occurs when the time used by the OCP and the time used by the JTIDS network are the same (within certain tolerances). Because a master terminal defines the time used in the network, it is synchronization and therefore has established communication with the network as soon as the operator has entered time. For all other terminals this synchronization must be achieved over three distinct steps: net entry, coarse synchronization and fine synchronization using one of two methods of synchronization, and Passive Timing (PT) or Round Trip Timing (RTT).



(1) RESIDES IN CP COMPONENT OF TPU: HMP 1116.
(2) RESIDES IN TMSS'S HMP 1116.
(3) RESIDES IN DG ECLIPSE S/200.
(4) RESIDES IN INTERDATA 8/32.
(5) RESIDES IN IBM 4331.
(6) RESIDES IN JSE'S HMP 1116.

Figure 4-7. HIT Software Classification Tree

During initial net entry a terminal uses the time plus time uncertainty estimate entered by the operator to listen to network activity occurring in prespecified time slots and prespecified nets. Once an error-free message has been received in any one of the prespecified slots, the terminal achieves coarse synchronization. It then activates either passive synchronization or round trip timing (depending on operator selection) to achieve fine synchronization.

In passive synchronization mode, position data in received messages along with the prior knowledge of time-of-transmission plus own terminal position estimate supplied by the user interface or the operator is used to determine net time. In RTT synchronization mode, the terminal issues an "RTT Interrogate" message to some other terminal on the same net. The other terminal responds in the same time slot with an "RTT Reply" message. The terminal then uses time of transmission, time of receipt, and information contained in the reply message to calculate the current value of net time and applies this time to the terminal.

Once communication between the user terminal and the JTIDS network has been established, it is maintained by the terminal's continuing synchronization process. The master terminal maintains absolute system time and participant terminals continue with either PT or RTT mode synchronization.

Control of communication is based on various parameters entered by the HIT operator or from the E-3A Data Analysis Programming Group (DAPG) via the Control Power Supply (CPS) interface.

- Transmission net number and time slot assignment - specified times for transmission of messages originating at a given terminal plus the net number for these transmissions.
- Relay time slot and net number assignment - specified times and net numbers for receipt of messages originating at and destined for other terminals plus times and net numbers for retransmission of such messages.

- Message receipt time slot and net number assignment - specified times and net numbers for receipt of messages. (A-1 unassigned time slots are used by the terminal to receive messages on the same net used by the terminal for transmission.)

- Transmission mode - terminals may be set into radio silence, in which no transmissions may take place, or in polling mode, in which transmissions may take place only when polled or when necessary to maintain synchronization.

The HIT OCP is divided into several major software functions: control, signal processor, control display panel, translator processor (ACE OCP only), control power supply (E-3A/HIT OCP only), recording, fault detection, inertial navigation, source selection, and filter.

The Control function controls execution, initialization, and re-initialization of the OCP, and establishes or re-establishes communication with the SP, CDP, R/R, and Adaptable Surface Interface Terminal (ASIT) translation processor.

The Signal Processor (SP) function provides the proper management and operation of the terminal as part of the JTIDS network. This includes establishment and maintenance of synchronization, communication, input and output, relaying, clock control, response to net management commands, and round trip timing interrogations. All inputs to the Communications Processor (CP) from the SP, and all outputs to the SP from the CP will be handled by this function.

The Control Display Panel (CDP) function accepts, interprets, formats, and processes operator inputs from the CDP. Additionally, this function formats and outputs messages and/or prompts to the CDP input.

The Translator Processor (TP) function establishes and controls the flow of messages over the TP-CP interface, including the sequencing and transmission of messages to the TP and the receipt of messages

from the TP for both transmission over the net and control of the TP. Exchange of status messages between the CP and TP is also controlled by the TP function. (ACE OCP only).

The Control Power Supply (CPS) function establishes and controls the flow of messages over the CPS-CP interface, including the sequencing and transmission of messages to the CPS and the receipt of messages from the CPS for both transmission over the net and control of the CPS. Exchange of status messages between the CP and CPS is also controlled by the CPS function. (E-3A/HIT OCP only).

The Recording function provides the capability to format, buffer, and record specified data on the R/R. Data to be recorded include error statistics, received messages, and transmitted messages.

The Fault Detection function monitors terminal and communication status information passed from the other functions, and generates CDP alerts and queues prompts for designated fault conditions.

The Inertial Navigation function provides for interfacing the OCP with the inertial adaptor unit and for processing of the inertial navigation data. The data is input, error checked, and then processed into a format that is acceptable as input to the filter function. The inertial navigation function is also responsible for maintaining the terminal's position information that is output by the SP function via position messages.

The Source Selection function is responsible for selecting position messages to be used by the filter function. The source selection function also collects potential RTT donors for use in performing RTT interrogates. All received position messages and N7-1 test messages are checked for possible filter or RTT use.

The Filter function processes received position message or RTT data along with data from the inertial navigation function. This input data is used to maintain a set of position, velocity, time, and inertial platform error states and associated covariances. In addition, the filter function computes the terminal's position and time qualities. The filter function output data is used by the source selection, inertial navigation, and SP functions.

HIT Support Software. The support software for the HIT OCP is a ground based software set whose function is to develop and maintain the HIT OCP. This support software set will be operable within the JTIDS integrated support facility at WR-ALC.

The HIT OCP support software systems are operational on the IBM 4331 mainframe computer, the Interdata 8/32 minicomputer, the Hughes HMP 1115 minicomputer, and the Data General Eclipse S/200 minicomputer. The support software used in OCP development and maintenance consists of both real time and non real time software. These software tools include computer interface simulations, source language translators, data reduction programs, scenario tape generators, PROM burn programs, computer program debug packages, and the various computer operating systems. These software tools are employed within the JTIDS ISF to construct and validate operational computer programs.

The real time support software provides for real time mission simulation to test the HIT OCP in a laboratory environment. The laboratory facilities required for real time testing of the HIT OCP are the HIT, the JTIDS System Exerciser (JSE) with its associated software, the Hughes HMP 1116 minicomputer with its associated operating system, the Data General Eclipse S/200 minicomputer with its associated operating system, the Simulation OCP/Test OCP (SOCP/TOCP), and the TDMA Message Processor OCP (TMP OCP).

The SOCP/TOCP is hosted on the HMP 1116 minicomputer in the TMSS and provides a simulated ASIT TP interface to the HIT TPU, or inputs to the RF side of the Signal Processor (SP) in the TPU. The OCP is hosted on the Data General Eclipse S/200 minicomputer and provides a simulated control power supply interface from the E-3A aircraft to the HIT TPU. The JSE provides the capability to test the HIT OCP in a multiple user JTIDS net environment within a laboratory.

The SOCP/TOCP provides a simulated Signal Processor (SP), two simulated Translation Processors (TP), a simulated Inertial Adaptor Unit (IAU), a scenario tape input, and an on-line CRT operator interface for controlling a simulation environment during ACE with RELNAV Operational Computer Program (OCP) exercises. The SOCP/TOCP, by residing in a different computer than the OCP, allows for real time operation of the OCP and during such operation permits realistic exercise of the I/O functions.

The TMP OCP will simulate and support one or two HITS as if the terminals were operationally connected to an E-3A. It will (1) establish initial communication with the terminal(s) in accordance with defined procedures, (2) generate and output intercomputer messages containing the necessary data to support normal terminal operation, (3) input and perform certain checks in intercomputer messages received from the terminal(s), (4) accumulate counts of messages transmitted, messages received, messages received with errors, and (5) provide printout of selected message data.

The JSE has the capability to create a JTIDS net within a laboratory environment. Some of the net participants are real terminals and some are simulated by the JSE. Such things as net entry, obtaining fine synchronization using either Round Trip Timing (RTT) or Passive Timing (PT), and the affect of dynamic time slot reassignment can be evaluated. This allows the HIT OCP to be verified and validated while operating in a real time operational JTIDS net environment.

HIT OCP non real time support software is comprised of operational computer program development tools, SENEGER, DATAREDT, and a PROM burn program.

The OCP development software consists of cross assemblers, linker/loader, and related utilities which are used to edit and translate the operational computer source language programs into executable load modules. This software is hosted on the Interdata 8/32 mini-computer.

SENEGER is a scenario tape generator that is used to script a simulation scenario tape. SENEGER is hosted on the IBM mainframe computer. The scenario tape is read by the Hughes HMP 1116 mini-computer configured as the Simulation Test Processor (STP) to simulate either an E-3A interface or ASIT interface.

DATAREDT is the data reduction program for analysis of the HIT embedded computer, operational computer program, and system performance data generated during simulation testing. This computer program processes, consolidates, and displays test data recorded during validation testing of the OCP. DATAREDT is hosted on the IBM mainframe computer.

The OCP for the HIT terminal will be contained in PROM's. Changes to the OCP will require the capability to burn new PROM's for the HIT terminal. This requires a PROM burn program and a device to perform the programming of the new PROM.

HIT Test Software. Hughes Aircraft Company has developed a suit-case tester for the HIT terminal. Associated with this portable tester is test software. The suitcase tester with its associated software is used to isolate terminal malfunctions.

There are two debug packages, AIDS and CLUB which are listed on the Interdata 8/32 minicomputer. They provide on-line debugging for application testing.

ASIT Software Description

ASIT Operational Software. ASIT software is comprised of three distinct functional categories: Operational Computer Program (OCP), support software, and test software. These categories are depicted in the ASIT software classification tree of Figure 4-8.

ASIT OCP is the computer program which resides in the IBM ML-1 computer and serves to control the ASIT subsystems for translation of JTIDS messages to TADIL B messages and vice versa. The ASIT OCP is partitioned into several major software functions: system control, translation, adaptation, performance monitoring, recording, and simulation.

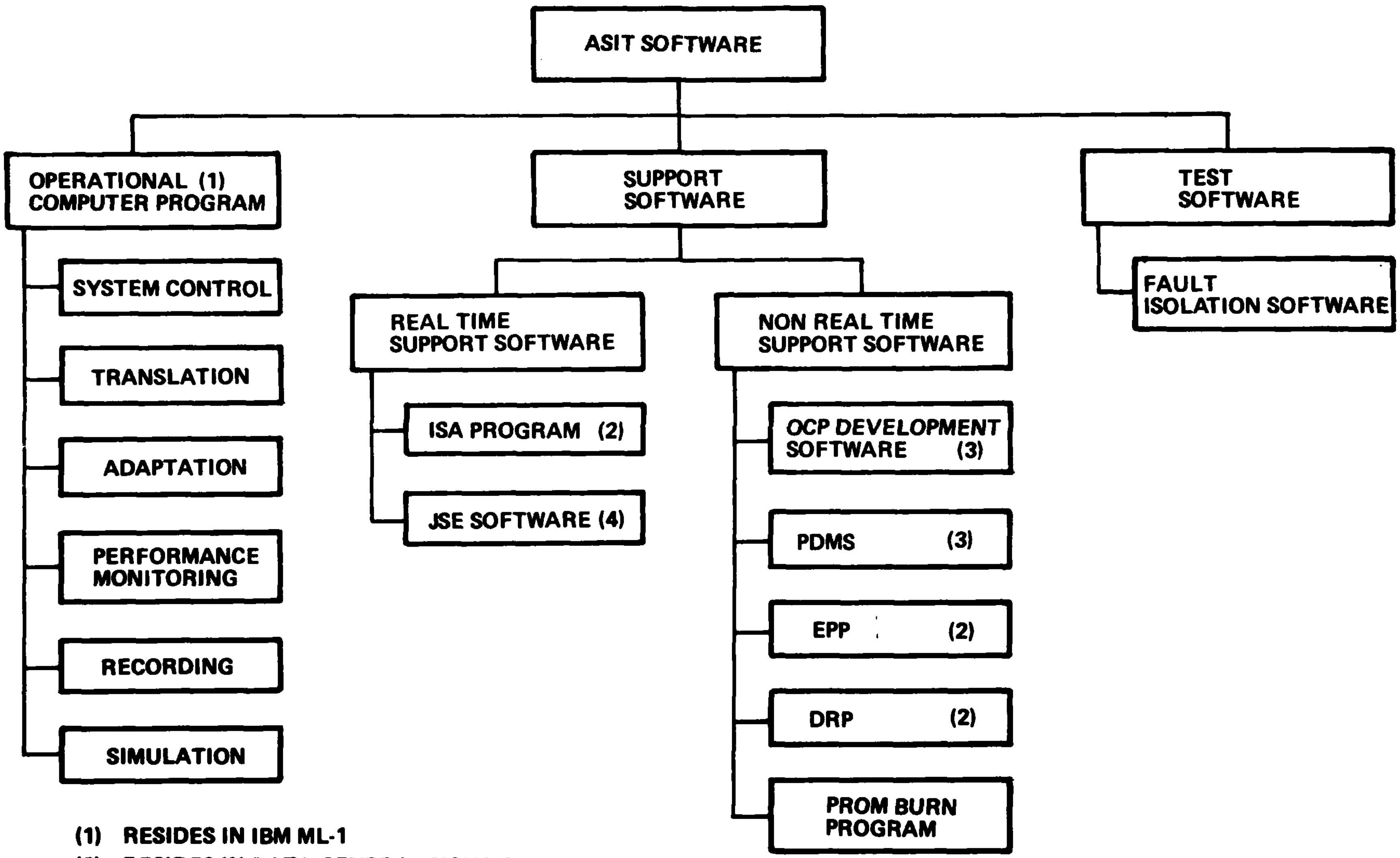
The System Control function is responsible for initialization and restart, interfacing with operator I/O, data management, task management, processing interrupts, I/O control for the peripherals, and executing the built-in-test program.

The Translation function is responsible for message filtering, surface subscriber interface maintenance, JTIDS interface maintenance, packing and unpacking, and performing the translation of JTIDS messages to TADIL B messages and vice versa.

The Adaptation function is responsible for processing adaptation parameters and handling control display panel replication commands for the HIT.

The Performance Monitoring function is responsible for error statistics, message statistics, monitoring surface subscriber interface, monitoring JTIDS interface, monitoring built-in test program results, and preparing alarm messages.

The Recording function is responsible for processing operator commands to start and stop recording, managing recording buffers, preparing data for recording, and building the records to be recorded.



(1) RESIDES IN IBM ML-1
(2) RESIDES IN DATA GENERAL NOVA 3D.
(3) RESIDES IN IBM 4331.
(4) RESIDES IN JSE'S HMP 1116.

Figure 4-8. ASIT Software Classification Tree

The Simulation function is responsible for analyzing the input records, transferring simulation messages to the input buffers at the calculated time, and creating simulated interrupts.

ASIT Support Software. ASIT support software is a ground-based software set whose function is to develop and maintain the ASIT OCP. The ASIT support software set will be operable within the JTIDS integrated support facility at WR-ALC.

ASIT support software used in OCP development and maintenance consists of both real time, and non real time software. These software tools include computer interface simulations, source language translators, data reduction programs, etc., which are employed within the JTIDS ISF to construct and validate operational computer programs. These support software systems are operational on the IBM 4331 mainframe computer and Data General NOVA 3B minicomputer.

The real time support software is a variety of software tools which provide for real time mission software testing in a laboratory environment. The laboratory facilities for real time testing of the ASIT OCP will include the ASIT with the embedded IBM ML-1 computer, a Hughes Improved Terminal (HIT) with its operational computer program, JTIDS System Exerciser (JSE) with its associated software, the Data General NOVA 3D minicomputer with the associated RDOS operating system, and the Interface Simulation Analyzer (ISA) program.

The ISA is hosted on the Data General minicomputer and provides a simulated HIT interface, or surface subscriber interface to the ASIT. The JSE provides the means to interface the ASIT into a JTIDS net within a laboratory environment. ISA is a software package which uses a previously prepared scenario tape to pass/accept simulated surface subscriber messages to/from the ASIT or pass/accept HIT messages to/from the ASIT. ISA can simulate one or both interfaces at once. ISA also provides responses to the periodic test messages that ASIT sends across both the surface subscriber and HIT interfaces.

The JSE provides the means to create a net with multiple users in a laboratory environment. Some of the users will be simulated by the JSE and others will be real. The HIT, interfaced with the ASIT, will be one of the real users on the net. This will enable the ASIT OCP to be verified and validated when used within a JTIDS net and will ensure that interoperability is maintained. Also, this will ensure that operator inputs at the HIT, dynamically changing transmit and receive time slots, remain compatible to the ASIT OCP. The JSE also gives the ability to duplicate in a laboratory scenarios that occurred in the field and caused problems.

ASIT non real time support software is comprised of operational computer program development tools, Exercise Preparation Program (EPP), Data Reduction Program (DRP), and PROM burn program.

The OCP development software consists of Program Development and Maintenance System (PDMS), cross assemblers, linker/loader, and related utilities which are used to edit and translate the operational computer source language programs into executable load modules. This software is hosted on the IBM 4331 mainframe computer.

The EPP is hosted on the Data General minicomputer. EPP provides the capability to script the scenario tapes to be used by ISA for surface subscriber and HIT interface simulation.

The DRP provides the capability for detailed static analysis of the ASIT embedded computer, operational software, and system performance data generated during system simulation. This software processes, consolidates, and displays test data recorded during validation testing of the operation computer program. DRP is hosted on the Data General minicomputer.

The ASIT contains computer programs in PROM's for the Intel 8080 microprocessor which controls the Bus Interface Modules (BIM). Changes to these computer programs will require the capability to program new PROM's for the BIM's. This requires a PROM burn computer program and a device to perform the programming of the new PROM.

ASIT Test Software. Test software for the ASIT is the Fault Isolation Software (FIS). FIS is used to locate the source of a malfunction in the ASIT. This software operates in the IBM ML-1 computer embedded in the ASIT. It is limited to isolation of faults other than ones in the ML-1 computer itself.

4.5.2.2 Hardware Support

ASIT hardware will be maintained at Warner Robins in a repair depot on base. Hardware repairs will require testing to verify the repair. Repair testing will require some means to drive the inputs to the ASIT with TADIL B on the subscriber interface and with JTIDS messages on the HIT interface. An ISA will provide the means to drive both these interfaces.

The ISA will be an integral part of the Warner Robins' ISF. It will be vital to Warner Robins' ability to support JTIDS and an asset to the Air Force. Warner Robins will use the ISA to support maintenance of the BIM's, to test the support programs for the ASIT, to do data reduction for JTIDS, to support the hardware repair depot, and to provide a capability to back up TAC for support of the ASIT TP OCP.

4.5.3 Support Posture Evaluation

The overall support system for JTIDS is unique in that it not only is operated by two commands (TAC and AFLC) but is also composed of three major elements located at three different USAF air bases. The main element at WR-ALC is connected to the TACS/TADS support facility at Langley AFB which is in turn connected to the E-3A support facility at Tinker AFB. The connections are via TADIL B links. This distribution of equipments over three facilities will create a need for added coordination. For example, if the WR-ALC (MMEC) personnel wish to connect the TACS/TADS equipment at TAC/Langley, they must first ensure that TAC/ADY personnel have not scheduled it for other analyses or uses. There may also be competition for use of the TADIL B links.

Despite such obvious problems, if the JTIDS ISF is completed as currently planned it will provide sufficient capability to support the system's CPCI's. The software change procedures for AFLC supported computer programs relative to initiating change requests, screening and reviewing these requests and recommended fixes, conducting development and operational tests, and distributing CPCI changes will follow the policy guidance of AFR 800-14 (Volume II) and AFLCR 800-21. TAC procedures will follow the guidance of TACR 171-24. The O/S CMP, when written, must meld these configuration management procedures into a total system support package.

Table 4-8 presents an assessment of the adequacy of the planned JTIDS support posture when compared to the ECS support requirements presented in Section 2. The comments are grouped into the same six functional areas in which Section 2 has grouped the support requirements.

Table 4-8. JTIDS Support Posture Status

Support Requirement	Findings/Remarks
ECS Change	The CRISP describes a detailed change coordinating and support cycle in addition to the projected resources required to support the JTIDS CPCI's. This coordination cycle and the multicommand/service configuration management system must be expanded upon in the O/S CMP. Both TAC and AFLC will be responsible for maintaining portions of the JTIDS software.
Change Analysis and Specification	This process is fully covered in the CRISP's published to date. The Class 2 and Class 3 Terminal CRISP's have not been written.
Engineering Development and Unit Test	The JTIDS ISF, when implemented, should provide a capability for developing new or revised code for integration and testing.
System Integration and Test	Complete integration and 100 percent verification of software changes to either the HIT or ASIT software CPCI will require that at least the TADIL-B links between WR-ALC, Langley, and Tinker be operational. Additionally, it may also be required that the E-3A aircraft participate in a flight test verification.
Change Documentation	AFR 800-14 prescribes that CPCI's and related documentation be assinged a CPIN number. Whenever a change is made to a CPCI the appropriate CPIN number for the Computer Program Documentation Package (CPDP) must be supplemented with a revision number (Rev 001 through 999). WR-ALC/MMEC and TAC will each be responsible for maintaining and updating their respective portions of the JTIDS baseline CPDP. Having two baseline documents will complicate the configuration management problem and make V&V more difficult. Every effort should be made to consolidate configuration management when the O/S CMP is written.
Certification and Distribution	AFR 800-14 requires AFLC to distribute CPCI changes through the TCTO system. Using commands are allowed to develop their own distribution control system. The relationship and interface between these two distribution systems should be clearly defined in the O/S CMP.

5. ASSESSMENTS AND DISCUSSIONS

5.1 INTRODUCTION

The ever expanding use of minicomputers and microprocessors to generate and control specific weapon system functions has produced a new class of management problems for C-E systems managers. In the past, computers have been used to process and display raw data, but were not embedded within the system to the same extent as today. This switch from data processing to system's control has been relatively rapid in C-E systems. For example, in the last four years only six embedded computer systems underwent PMRT. In the next four years over twenty-five systems could be transitioned. The traditional management organizations are not equipped to cope with this expanding mission, digital technology, or the complex support problems associated with highly dynamic ECS systems.

In the following paragraphs, the problems which were identified during the detailed review of the representative C-E systems discussed in Section 4 are examined and commented upon.

5.2 GUIDANCE AND PLANNING

One of the major management problems evident throughout the baseline evaluation was the failure of weapon system developers, operational users, and supporting agencies to follow the policy and guidance contained in AFR 800-14 Volumes I and II. The Computer Resources Working Groups (CRWG's) are not preparing adequate and timely Computer Resource Integration Support Plans (CRISP's) nor the follow-on Operations/Support Configuration Management Procedures (O/S CMP). The CRISP must be started very early in the system's acquisition cycle to ensure the earliest possible identification of support resources.

The O/S CMP should be prepared during the full-scale development phase before the C-E system begins its operational life. This document is critical to the effective configuration management of an ECS system and, in fact, is an agreement between the using and supporting agencies apportioning support resources according to specific weapon system needs and requirements. To determine the scope of the problem the C-E systems scheduled to be supported by SM-ALC between 1980 and 1984 were examined. Table 5-1 summarizes the results of this survey. Of the seven systems which are in the production/ operational phase only one has a signed CRISP and not one system has a signed O/S CMP.

If the CRISP's for all these C-E systems were completed on schedule, C-E logistics planners would have a compilation of ECS support requirements for the next four years. With these support requirements agreed upon, plans could be developed to procure the necessary resources and build the required facilities. In fact, the CRISP's should be prepared in sufficient time to permit the program manager to incorporate CRISP requirements in the full-scale development contracts, thereby relieving the burden put on the ALC's to provide unfunded support resources.

The publication of AFLCR 800-21, January 1980, will greatly assist the rapid development of CRISP's and O/S CMP's, however, it could go much farther by defining the minimum AFLC support level for each ECS system category. This recommendation will be expanded upon in subsequent paragraphs. Additionally an annex should be included in AFLCR 800-21 giving representative examples of how resources should be identified. CRWG representatives often are unfamiliar with the CRISP writing process and the level of detail required. For example, the AN/GPN-24 CRISP simply states HQ AFLC will identify the number and type of people to support the

Table 5-1. SM-ALC CRISP and O/S CMP Status (C-E only)

System Status†	CRISP			O/S CMP		
	Signed	Draft	None	Signed	Draft	None
In production or operational	1	6	-	-	5	2
Under design or development	3	9	2	-	8	6
Test and evaluation	1	4	-	-	5	-

† Twenty-six systems scheduled to PMRT between 1980 and 1984 were examined, data as of April 1980.

system and program them in future allocations. In constrast, the SEEK IGLOO CRISP identifies the number of people and skill levels required. The SEEK IGLOO CRISP also gives a description of the training required, whereas the AN/GPN-24 GRISP simply states training is an ATC responsibility, assuming trained people will be provided.

Another area of critical concern is the division of ECS support responsibility between operational users and the ALC's. AFR 800-14 states that ECS system hardware and software components should be managed as an integral system. Despite this policy many exceptions can be found where the operational user maintains significant ECS configuration control. A review of current CRISP's revealed the range of ALC support went from full responsibility for all ECS software to only producing PROM's from user supplied software. The latter role reduces the SM's control over configuration management. He is often put into the position of "rubber stamping" system changes, sometimes after the fact. As a result, effective integrated system configuration management becomes difficult, if not impossible, and system's life cycle costs are increased because system management and software support are not centralized.

From an historical perspective the problem develops when the operational user believes weapon system capability is enhanced if the using command maintains control over the software, often ignoring the requirement for hardware/software integration. This integration requirement is often overlooked in the heat of CRWG discussions on responsiveness. Responsiveness is a highly emotional term which in many instances cannot be qualified by the user in terms of weeks, days, or hours. In the ECS area there are few examples of AFLC's "responsiveness" to cite due to rapid advance of digital systems. Oftentimes the user is uncomfortable with digital systems and feels more secure if the software is under his control. Because of this uneasiness and the fact that AFLC has not established a firm ECS support track record, the operational commands are reluctant to accept AFLC's new combat support role.

During the initial CRWG support discussions the user comes well prepared to defend his position, often enlisting the aid of the SPO and the contractor to support his preconceived operational requirement. The AFLC representative is often locked into a defensive position by the lack of definitive guidance on the minimum support level that AFLC can provide for the specific ECS category. If he had an established AFLC command position on the level of ECS support which will be provided, the AFLC representative could then negotiate from a position of strength. It would be up to the user to defend his position for deviating from the published baseline.

This baseline ECS support position could help relieve some of the user's concern as to the level of AFLC support he can expect and it would also give the SPO a minimum ISF configuration it must support. Additions can be made to the baseline support package as the CRISP takes form; or when the user has a justifiable operational need AFLC can grant the user operational control over portions of the ECS software. This procedure would put AFLC back in control of system configuration management rather than trying to wrestle control from the operational user.

Additionally, it is proposed that AFLC take an active role early-on in the conceptual and validation phases of system acquisition. AFLC attendance at all DSARC's and technical review meetings is extremely important. The purpose of this early participation is primarily related to (1) ensuring that the system design approach employs as much standardization as possible to minimize deployment phase support cost and complexity, (2) learning the support requirements so as to initiate staffing plans and preliminary ISF designs, and (3) providing support for the position that AFLC should be assigned responsibility for providing the necessary software support. As an example, it is believed that such early and continuous participation in the SEEK IGLOO program led to SM-ALC being assigned as the support organization.

On the other hand, lack of early and continuous participation in the JSS program led to ADTAC being assigned the support role instead of SM-ALC. The premise here is that AFLC is best equipped to provide the required software support. If not, then the user should be assigned the support responsibility. In addition to merely attending the early design review meetings, AFLC should be prepared to provide the rationale for using standardized computer architectures and languages. The best rationale is, of course, evidence that life cycle costs are minimized if a standardized approach is followed.

Chapter 3, "Planning", of AFR 800-14 describes the issuance of a Program Management Directive (PMD). This document establishes direction relative to items such as standardization and identification of CPCI's. A key problem is that inadequate attention is paid to such overall guidance.

Regarding standardization, there is little evidence that AFLC has been successful in attempting to influence the design process with respect to standardizing either computers, computer architectures, or computer languages. Success in such attempts would allow significant software support cost savings over the lifetime of the system.

DOD has recognized the potential benefits of standardized languages and thus has approved three High Order Languages (HOL's) for use in new defense systems. These languages are identified in DOD Instruction 5000.31, "Iterim List of Approved High Order Programming Languages," They are: JOVIAL J73, a language specified for AF ECS's; ATLAS, a language used for ATE software; and Ada, a new language to be used for all military software as soon as it is available. DODI 5000.31 also defines two computer architecture standards: MIL-STD 1750A, "Military Standard, Airborne Computer, Instruction Set Architecture", and MIL-STD 1862, "Military Standard, Instruction Set Architecture for the Military Computer Family."

MIL-STD 1750 is a 16-bit word Instruction Set Architecture (ISA) primarily for avionic applications; while MIL-STD 1862 is a 32-bit word ISA primarily for tactical C^3 applications. These standards define the

instruction set such that any program written in the standard computer language will execute on any computer conforming to the standard. Thus, these standards define the interface between the software programs and the specific hardware implementations.

In many cases, CPCI identification and designation (as a line item in the contract schedule and a data item in the CDRL) is inadequate. Proper CPCI identification is important because it is the software entity that the procuring activity actually buys from the contractor and because software development contractors are managed largely by managing their CPCI's. The CPCI identification process, usually called "CPCI selection" in Government documents, has two basic steps: (1) identification of the total set of deliverable software processes or functions and (2) grouping of these processes or functions into CPCI's.

To properly identify contractually deliverable software, the following three rules generally apply:

- Include in the contract as deliverable items all operational software and all test and support software, including firmware, data, and proprietary items, that are required to cost-effectively use, operate, modify, or maintain the system over its life cycle†
- When the cost effectiveness of a required item of test or support software cannot be determined, include in the contract an option to acquire it later‡.
- Test or support software that is required only during development need not be specified as contract deliverables unless their development or use has a strong direct affect on items designated as deliverables.

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† This rule is based on DODD 5000.29; paragraph V.E; AFR 800-14, Volume I: paragraph 3i; AFSC Supplement 1 to AFR 800-14, Volume I: paragraphs 3i and 3m(8).

‡ This rule is based on AFSC Supplement 1 to AFR 800-14, Volume I: paragraph 3i.

Cases have arisen where improper attention to these rules and guidelines has led to situations wherein a necessary computer program was not delivered because it was not properly identified as a CPCI. Such inadequacies usually involve either test or support software, however, and not operational software. Problems of this type can be avoided and all software necessary to support the system's operational computer programs will be available at PMRT by having the software engineer from the responsible ALC attend the relevant technical review meetings.

Once the system engineer has developed a good understanding of how the system will function, its intended operational environment and user support concepts, he is better prepared to successfully negociate changes to the established minimum support baseline. At this time he should have sufficient knowledge of the system to identify ISF unique requirements, such as support libraries, intelligence data bases, ISF integration software, diagnostics, etc. For example, cases have arisen where a software "support" program was known to be needed but not specified as a deliverable CPCI. The contractor had to have developed it for his own uses, but because it was not specified as a CPCI his documentation, if any, would be sparse. The result is that the support organization, perhaps after some pleading, is given a tape or a box of cards with no supporting documentation. The solution to such problems is to have AFLC's software engineers be knowledgeable enough to specify and insist on all necessary computer programs and supporting documentation.

5.3 SHARED SUPPORT RESPONSIBILITY

Section 5.2 alludes to problems encountered when a using command had total responsibility for supporting a system's software. Unfortunately, even more problems can arise when the support responsibility is shared

between AFLC and the user. For example, in the case of E-3A AWACS both OC-ALC and TAC's 552nd AWACS Wing are involved in the support of operational software. Furthermore, in one case they even share the responsibility for supporting a single airborne computer program. The Systems Maintenance Computer Program (SMCP) is supported by TAC; however, the SMCP fault trees that are a part of the SMCP are supported by AFLC. The Fault trees are an integral part of the SMCP in that they are part of the monitor and test subsystem control function of the SMCP. Because the OC-ALC ISF is not yet operational, no specific problems have been encountered; however, one can predict that there will be, at the very least, a considerable increase in intercommand coordination than would otherwise be required.

When shared responsibilities are not adequately covered in a coordinated and signed O/S CMP, a number of configuration management problems develop which can affect systems performance. ECS systems are usually small computer systems with a set memory size and throughput capacity. Any change/addition/deletion to the baseline CPCI, whether by the user or ISF engineers, affects the allocation of this limited memory resource. Uncontrolled changes can often consume the growth memory allocated for future functions. In some cases the user and IFS engineer are competing for the same growth memory space. In addition to affecting memory allocation, software modifications can cause a change in throughput rate or real time processing priorities. If this happens, a small change in a real time program could ripple through the whole system throwing off timing and destroying systems capabilities. Software/hardware integration is a critical element and must be considered when determining who should support the software. Integration testing must be fully covered in the O/S CMP.

Additionally, when ROM's and PROM's are used to host software changes/additions/deletions there is a hardware configuration management impact. If a change affects ROM's/PROM's on more than one

PC board within the system or numerous ROM's/PROM's on the same board, the configuration management problems can become extremely difficult to solve. Due to the limited size of the ROM's/PROM's and the compact nature of PC boards, there is insufficient space to list all the information required to identify which software version is encoded in the PROM on the PC board. Problems arise when Version 3 PROM's on the PC board A will not work if Version 1 PROM's installed on a companion PC board B. Considering the number of systems and versions possible, the control of PROM supported C-E systems is a major task for item managers.

An additional consideration is the affect a PROM change can have on system ATE. Until the ATE program is changed it will be impossible to automatically check the system. Any change to software controlling system functions should be carefully coordinated with the ATE system manager, a point sometimes overlooked by operational users until the system fails to work on the test stand.

Each of these representative problem areas must be fully addressed in a detailed and comprehensive O/S CMP or configuration management will be lost, with a result impact on weapon system performance.

Every effort should be made to prepare a comprehensive O/S CMP and ensure that the user understands the limitation of the Software Support Facility (SSF) concept. An ISF with built-in hardware integration capability is required to V&V critical software changes, especially in real time or highly integrated systems.

5.4 RESOURCE MANAGEMENT

The cadre of software engineers at each ALC is growing both in number and skill level, but the rapid proliferation of ECS systems is outstripping the availability of trained ECS support specialists. As a result the experienced ECS engineers are used on the most visible systems, i.e., those systems which are soon to undergo PMRT or are already operational. On the other hand, new engineers are often assigned to systems coming on line in two or four years. It is unfortunate that

these new and sometimes inexperienced engineers are selected to attend CRWG meetings. With little experience to call on they are at a disadvantage in dealing with support issues. Oftentimes the using command program manager has one to two years of experience with the systems. Due to the high turnover in the SPO, the CRWG representative may be managing his first program and not be familiar with AFR 800-14 and long term support requirements. As a result of his experience and knowledge, the user often takes control of the CRWG and describes a support system in the CRISP which favors the user rather than considering the long term life cycle software support costs.

This problem will partially resolve itself as more engineers and managers gain ECS support experience. However, consideration should be given to developing a CRISP and O/S CMP preparation short course for SM's and engineers. One of the handouts from the course could be a representative CRISP and O/S CMP. With initial training, an example to follow, and a baseline ECS support system description to guide activities, the AFLC representatives could significantly improve their CRWG participation and the resultant CRISP and O/S CMP. This early effort to prepare a robust and detailed CRISP should produce dividends throughout the life of the system.

The development of 50 or more ISF's with one for each C-E system employing embedded computers is a formidable task involving millions of dollars and hundreds of software engineers. In C-E systems sharing common computer families and architectures, consideration should be given to developing compatible ISF support stations that can serve two or more embedded systems. If each support station could handle two ECS systems, support hardware needs could be cut in half. Some manpower saving could also accrue, but not a 50 percent savings as each system has unique functions and capabilities.

The compatible support stations should be modular so they can easily be reconfigured and use system hardware simulators that can easil~~y~~ be exchanged with a real black box for integration testing and verification/validation. Each station should be capable of hosting a common set of software developed tools such as compiler, debuggers, diagnostics, etc.

One major impediment to the development of common support tools is the current funding system. Under current procedures money designed to support a specific system cannot be used to develop a common support station. Consideration should be given to studying the saving which would accrue from the development of compatible support stations. If the concept evaluation is positive, a prototype should be funded.

5.5 FUTURE REQUIREMENTS

In the 1980's, Air Force tactical communications systems will operate in an almost totally digital environment. The use of computers to process radar data and to control specific functions will expand as new technology becomes available to enhance weapon systems capabilities. This evolving digital communication and surveillance technology will be integrated into more sophisticated complex command and control systems. In the past, traditional AFLC support has met operational C-E needs in both peace and war; however, the introduction of highly flexible digital systems is straining traditional management structures. For example, system capabilities can be altered, degraded or enhanced with a few key strokes at a computer console, yet the documentation for this change may take months or years to produce and distribute to field units. The documentation system is geared toward long term hardware changes and not toward dynamic software changes.

Given the management problems produced by digital technology in C-E, the introduction of a DOD-wide C^3CM program in the next few years will exacerbate the problems faced by C-E ECS managers.

Near term C^3CM solutions will depend heavily on the flexibility and capability of ECS systems. Therefore, in addition to software updates required by normal use, the C^3CM program will drive a whole new class of C-E software changes. These changes will be driven by enemy reactions to our C^3CM capabilities and limitations. In this respect, C-E ECS support will become more like EW support. The ECS software may have to be changed whenever the enemy introduces a new weapon system or enhances an old one. Software change timing will become a function of available intelligence information rather than orderly scheduled block updates.

Traditional C-E management organizations have not been directly involved with intelligence processing, analysis, and distribution organizations. The full implementation and satisfaction of DOD C^3CM objectives will require the incorporation of intelligence related data in ECS software. This will require ALC's with C-E responsibilities to build and man appropriately cleared support facilities and provide means for the production and distribution of classified ECS data. In some cases, this ECS data may require compartmented access and physical control procedures. The planning for and procurement of proper facilities and special access billets is a time consuming process. Immediate action should be taken to fully define C-E's involvement in the C^3CM program and initiate action to plan C^3CM/C-E mission integration and support.

5.6 SUMMARY

The percentage of Life Cycle Costs (LCC) which are directly associated with the ECS portion of today's modern weapon systems is increasing rapidly, even as hardware costs are decreasing. One of the major contributors to LCC is the cost of maintaing the computer programs residing in the ECS's. A recent estimate has been made that the ratio of software changes to hardware changes for a system

currently under development would approach fifteen to one. Thus, it would seem that software maintenance costs will take an increasingly disproportionate share of total LCC. Significant cost savings can accrue if an improved ECS support management system can reduce the frequency at which software changes are made and/or increase the efficiency of the software change process.

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